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THE INSURRECTION IN CRETE.

THE entire civilized world is watching with great anxiety for the outcome of affairs in Crete. Though Americans are not directly interested in affairs in the Mediterranean, still they are almost universally in favor of a solution of the difficulties in the interests of Greece, the plucky little country that has dared to beard the iniquitous combination of oppressors called the "concert of Europe." It is but natural that the inhabitants of Crete should desire to have their historic island annexed to the Grecian kingdom, and it is little wonder that the Greeks consider that the Cretans are really Greeks held in bondage. It is to be hoped that the question will be solved quickly without re-

PRINCE GEORGE OF GREECE.

BEROVITCH PASHA, GOVERNOR OF CRETE.

TURKISH BATTERY OF ARTILLERY IN THE CITADEL OF CANEA.

course to a war which would embroil all the great powers and which would only end in a loss of hundreds of thousands of lives and incalculable treasure.

For the following particulars regarding the Cretan question we are indebted to the correspondent of the New York Sun, who writes from Athens under the date of March 5, 1897:

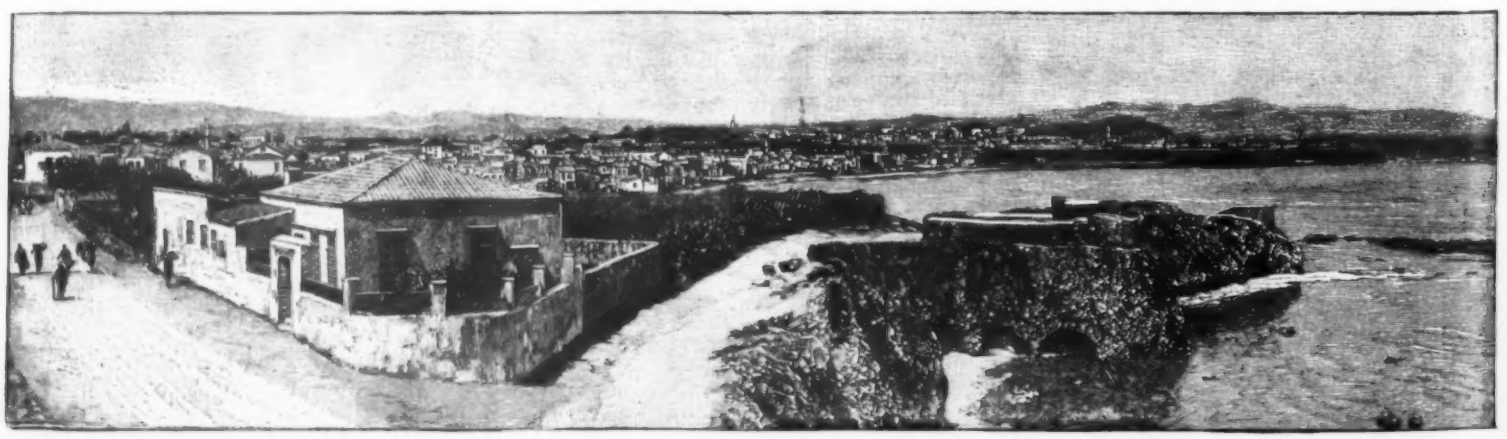
In September, 1895, the powers forced Turkey to determine upon certain reforms for the island of Crete. It is only recently that any substantial steps have been taken toward carrying out these reforms. A commission sent to Crete for the purpose of organizing the gendarmerie met with constant opposition from the Porte. The Christian population became impatient at the delay; the Moslems, on the other hand, were exasperated at the attempt to introduce into actual practice the paper reforms which they had every reason to believe would never be carried into effect. They were justified in this view by the attitude of the Sultan, who, with every means in his power, endeavored to misinterpret the proposed changes in the Cretan government and to prevent their actual application. In the mean time the island was left to manage itself without any police force to speak of. Major Borr, who was appointed by the International Commission, was prevented from entering on his work of organizing the gendarmerie until it was too late to re-establish order. Collected taxes which should have been turned into the treasury of the island were diverted to Stamboul.

Still the ambassadors at Constantinople kept pressing matters, and it became evident that a change was slowly being brought about in Crete, by which the Christian majority of the islanders were to have their share in the government. There seems little doubt that the Moslem population, as was the case in Armenia, were urged from Constantinople to make some resistance to the innovations.

At any rate, early in January of 1897, the Moslems in the vicinity of Rhetimo and Candia moved into these two towns, as always happens in Crete when hostilities are in contemplation.

The first act of violence was the killing of a Christian named Kambouraks just outside of Canea. This was followed by the murder of two Turks in reprisal at Halepa. The Moslem villagers now flocked into the town of Canea. On January 25 a Christian judge, Markoulakes, was shot from the window of a Turkish café. Canea was in a panic. Stores were closed and the small Christian population of the town barricaded themselves in their houses. Three days later a riot occurred among the Moslems. One whole quarter of Canea was burned, but, owing to their preparations, only about thirty Christians were killed and a few Moslems. Under the protection of marines all the Christian families of Canea were taken on board the European men-of-war and carried to the Greek islands. At present there are only about fifty Christians in

CHIEFS OF THE INSURRECTION, ISLAND OF CRETE.



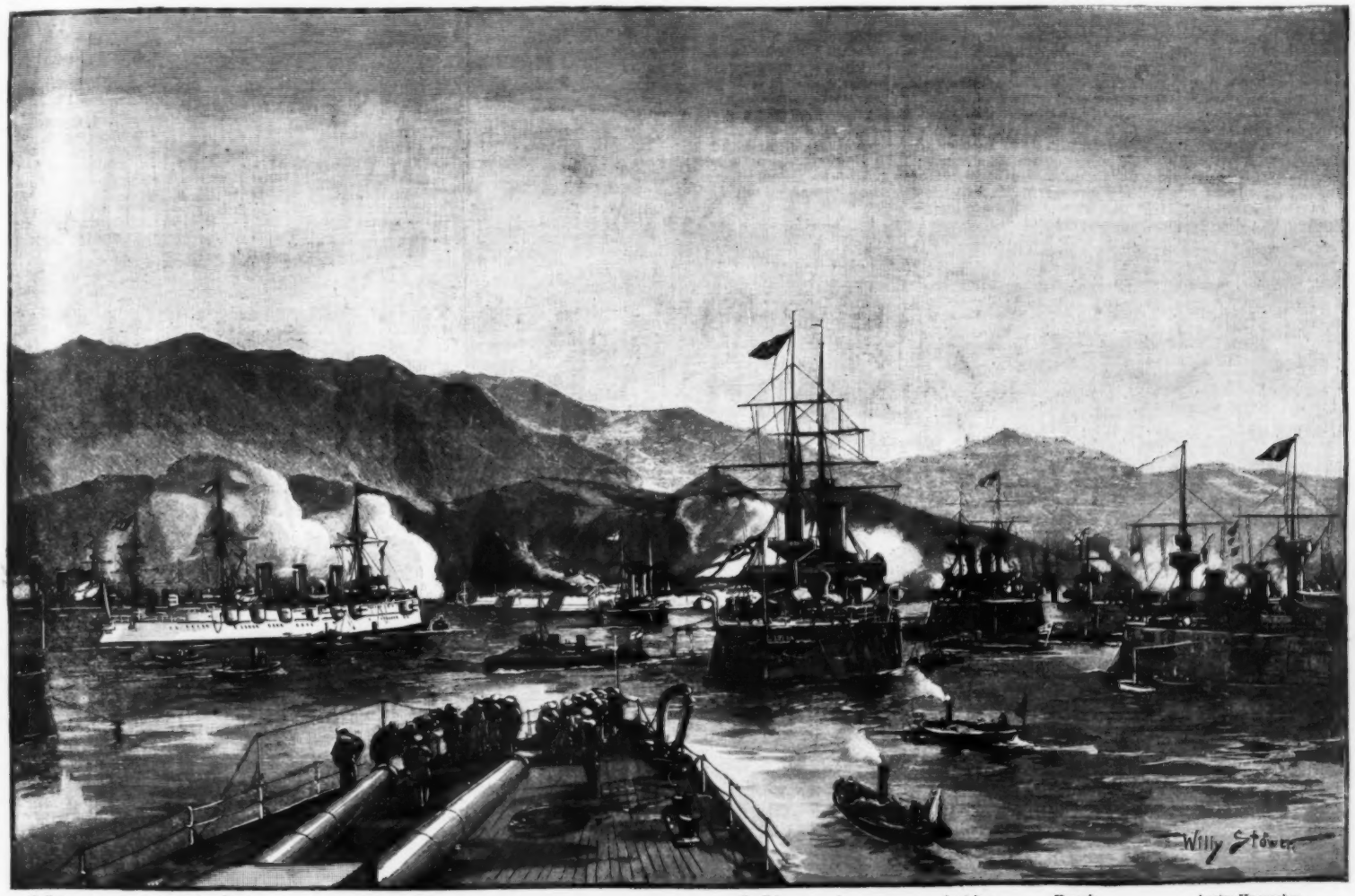
PANORAMA OF CANEA—VIEW TAKEN FROM HALEPA.

Canea. The mountaineers rose and came down to within a short distance of the town. The Moslem population had possession of the towns, the Christians of the rest of the island. Chaos reigned. The Turkish government was either unable or unwilling to cope with the situation. Engines sent from the foreign men-of-war put out the fire in Canea, but in no other respect did the European powers make any move to re-establish order.

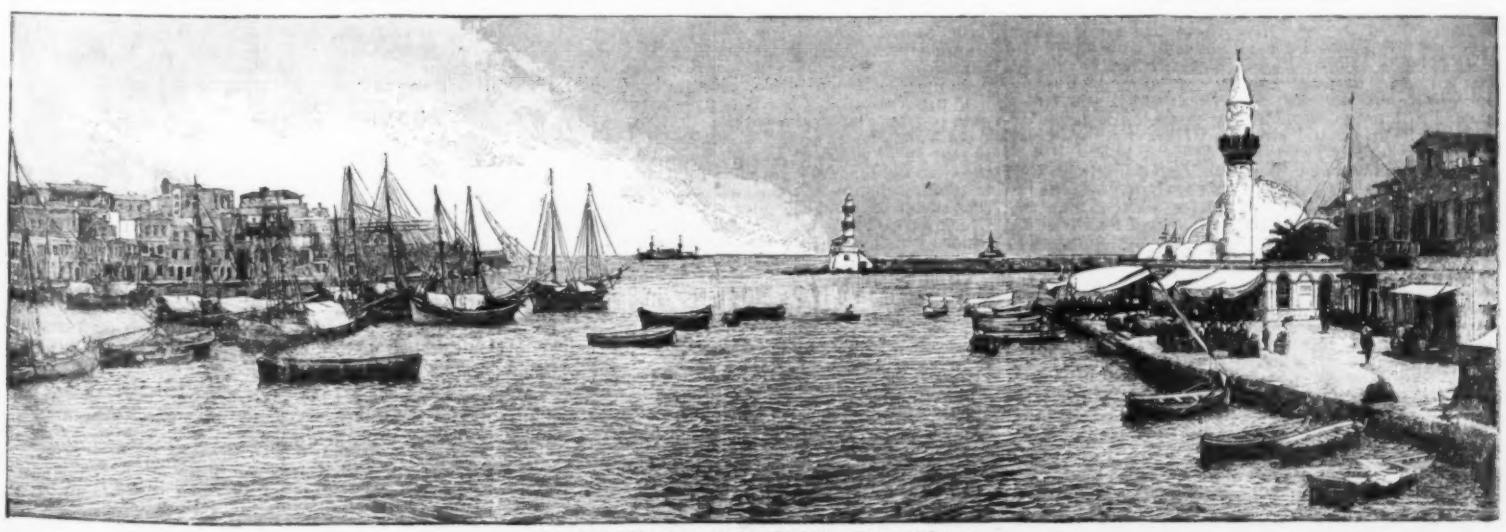
This state of things continued from January 28 until February 14, when Greece pluckily took matters into her own hands. Amid great enthusiasm 15,000 troops were embarked at the Piræus, and before Europe had time to interfere these troops were landed in Crete. Then only did the "powers" make up their minds that it was time to occupy Canea. This they did with marines from the men-of-war. At this point the ambassadors at Athens sent a diplomatic note to the Greek government deprecating the landing of troops and advising their removal. In spite of many reports to the contrary, the Greek Minister of Foreign Affairs insists that this is the only official communication on the subject made by the "powers" to Greece up to the present moment. The Greek government answered that troops had been landed to protect the Greek population of Crete, and that they could not be withdrawn. In the meantime, the Christian chiefs throughout the island raised the Greek flag and declared their desire for union with Greece. Col. Vassos, commander of the Greek army of occupation, issued a proclamation to the Cretans, in which he declared his orders to be to take possession of the island in the name of the King of the Hellenes. His first move was to send 400 soldiers to take the block house of Voukolies, which was occupied by 300 Turkish troops. On being summoned to surrender, the Turkish officer in command gave answer that so long as he had one soldier left he would defend his post. On February 17 the Greeks opened fire on the fort with their two mountain cannon, and by evening had greatly weakened the walls. However, for some inexplicable reason, the retreat from the block house on the east had not been cut off, and during the night the garrison escaped to Castellos, three hours distant, where 100 of them were taken prisoners on the following day. All the rest were either killed or escaped to Canea. This account of the engagement is from a Greek officer who was present and has just returned to Athens with the 100 prisoners. The latter are to be taken to Alexandretta and handed over to the Turkish government. This is merely a means to get them out of the island.

On February 19 the Turkish garrison of Coma, some 1,500 men, with about 2,000 native Moslems, started out to relieve the block house at Voukolies. Col. Vassos, however, anticipating the attempt, had placed about 200 Christian insurgents to guard the road on the heights at Monodendri. These men held the Turks in check until Col. Vassos came up with the main body of the Greek force, 1,100 men. The Greek troops, supported by eight mountain cannon, attacked the Turks at the bayonette and completely routed them, driving them back into Canea, where they were safe under the protection of the European men-of-war. After taking the block house of Aya, Col. Vassos withdrew, having orders not to disturb the European occupation of Canea. During these engagements the Greeks lost 30 men killed and wounded and 4 officers. The official report of Col. Vassos estimates the Turkish loss at Monodendri at about 100.

The account of this incident of February 21 is from an eye witness, who was on board the Greek man-of-war Hedra. To the east of Canea is a peninsula called Acroterie. On an elevation about five miles from the town is the Greek church of the Prophet Elias. A Greek flag waved from a wall near this church, and a body of Christian insurgents occupied the spot. Fifteen hundred yards west, toward Canea, was another church occupied by Moslem insurgents. Firing between these two churches began at 1 P. M., and increased in vehemence until about 5, when the crackle of musketry became an uninterrupted roar. Then the European fleet took a hand in the matter. The German boat fired the first shot, which landed within ten yards of a Greek gunboat anchored off Acroterie. The cannonade, in which the English, Russians, Germans and Austrians took part, lasted ten minutes. All the firing was directed against the Christians except one shell from the Austrian boat, which fell on the church occupied by the Moslems. The fire of the English was much the most accurate. The Greek flag was shot away, but a few minutes later was hoisted again at the same spot. The Moslem insurgents, encouraged by the action of the European fleet, tried to storm the church of the Prophet Elias, but were driven back. Fifteen Christian insurgents and three women were killed or wounded by the explosion of the shells from the European ships. There was no attempt on the part of the Christian insurgents to attack Canea. It was merely one of those fusillades between Christians and Moslems so common in the island. Under these conditions there seems no reasonable excuse why the fire of the European war ships should not have been directed against the Moslems as well as the Christians. The fact is, that the Turkish cannon from the fort also joined in the cannonade. This certainly showed a tendency in the agents of the great powers to support Turkey in her methods of dealing with the Christians of Crete which does not promise well for the Cretans.



THE EVENTS IN CRETE—THE SQUADRON OF THE EUROPEAN POWERS AT CANEA.



PANORAMA OF THE PORT OF CANEA.

The Greek consul in Canea was forced by threats of violence to lower the Greek flag on the consulate. Provisions have been sent to the Greek army of occupation in Crete. One transport was allowed to land provisions, but the other was prevented and seized. Even the medicines under the care of the Red Cross were at first prevented, but when an application was made for a written refusal the admirals decided to allow the landing of medicines.

The long expected diplomatic note of the six powers has at last been received by the Greek government. The government here is driven to the wall, without any chance of retiring with honor. This afternoon, in spite of the rain, a crowd of twenty thousand people gathered before the palace and shouted, amid waving of flags, for war.

The king did not appear, and the crowd made a rush for the door of the palace. For a moment it looked as if something serious might happen. Luckily, the crown prince came out at the most critical moment and spoke a few words to the mob. He assured them that the government was in sympathy with the people, and, after thanking them for their enthusiasm, asked them, considering the gravity of the situation, to go home and leave the king in peace.

There had been a feeling of hope here that Greece was secretly backed by one of the powers. This feeling has now given way to a determination to stick the fight out to the end, and, if necessary, to force the hand of Europe by throwing the army across the Macedonian frontier. Four more classes of reserves have been called out; this makes ten classes that have been called. Each class contains twelve thousand men. There are already sixty thousand Greek troops on the frontier.

It seems inevitable now for King George to go to the bitter end, otherwise he would run the danger of being driven out of Greece. Everything has been staked. The money reserved for paying the interest on the debt is being used in preparations. In case of failure, not only does national bankruptcy stare them in the face, but national dishonor, from which the Greek people will not recover for long years. A common expression heard on the street is, "If we fail, the Greek race is lost forever."

If Greece has come to an understanding with Bulgaria and Servia, the next two weeks may see the beginning of a European war. After all, one may say that the powers are entirely responsible for the situation. They failed to dispose of the Cretan question when they had the opportunity, and now that Greece refuses to stand aside and watch a repetition of the fiasco of last summer, they force her hand by the most uncompromising of diplomatic notes. The one thing most dreaded by the powers is the raising of the Macedonian question. Should Greece throw her army into Epiros, and Bulgaria and Servia follow suit in Macedonia, the situation would be beyond the control of diplomacy. It looks as if Greece would take the decisive step if she is summarily forced out of Crete.

Since the correspondent penned the above the events in Crete show little change or improvement. Greece at once began to mass troops and provisions on the Thessalian border, and on March 6 the last reserve, 100,000 strong, was called out. Volunteers from Sicily, Denmark and the United States started from their respective homes to join the Greek army in Crete. The note of the powers, referred to above, ordered Greece to withdraw their forces from Crete within six days.

On March 8 appeared dispatches giving Greece's reply to the powers. The firm and dignified reply urged the powers not to insist upon their scheme of autonomy and stated that the army of Greece should be kept in Crete till peace comes and then let the Cretans themselves decide their future. The reply to the identical note of the six great powers was not considered at all satisfactory. The powers were not immediately in accord as to what was best to do, some favoring drastic measures, while others were swayed by public opinion, which was almost unanimously in favor of a solution acceptable to Greece, and never before had public opinion so nullified the concert of Europe. Toward the 15th of March conflicting reports were circulated as to the blockading of the ports of Crete or even of Greece, but on March 16 all doubts were set at rest by notice of the blockade of the ports of Crete by the warships of the concerted European powers. Lord Salisbury announced England's approval of this action, and for this he was hotly rebuked by Sir William Harcourt, who said that such a disgraceful, abject answer had never before been given by a British minister to a British Parliament. The nation, he said, had never been exposed to a greater humiliation than it is now, when it is chained and coerced by the menace of wars in which it has no concern to abstain from doing what it is under the highest obligations of honor to do, and compelled to do what its conscience condemns.

On March 18, Mr. Gladstone's letter, written at Cannes to the Duke of Westminster, was published in London and was cabled to the United States. It created great excitement in London. It was almost a philippic in its denunciation of the concert of Europe and in its defense of the David among the nations which has dared to defy six Goliaths. Both as an argument and an appeal this latest and perhaps last utterance of Mr. Gladstone cannot fail to have a tremendous influence, even upon those wily diplomats who hardly like to be held up to scorn and derision by such a well known man of affairs as Mr. Gladstone.

On March 21 the formal blockade of the port of Crete began. The blockade applies to ships sailing under the Greek flag. Vessels sailing under neutral flags will be allowed to land merchandise on the island, provided that such merchandise is not intended for the use of the Greek troops in Crete, and is not destined for the interior; but these vessels may be overhauled at discretion by the warships of the international fleets.

To add to the excitement a Greek schooner was sunk off Cape Dia, Crete, by the Austrian gunboat Sibenico. The Austrian charge d'affaires at Athens explained the matter by saying that the schooner was fired upon because of an attack upon the gunboat by the Cretan insurgents.

According to the proclamation issued by the foreign admirals, the blockade of Crete began at 8 o'clock, March 21. It is apparent that the blockade is directed solely against the Christians in the interior and that the Moslems will suffer little inconvenience from the action of the six great Christian nations of Europe. It appears that the object of the blockading squadron is to prevent the landing of supplies of food, clothing, etc., destined for the starving Christians in the interior, while the Mussulmans who have flocked to the coast towns are allowed to land whatever they want.

The few Christians remaining here find it difficult to understand the motives that are prompting the powers to exert their energies to crush the Christian population of the island, while the Moslems have a free hand to do about as they please. About the only hope of the Christians outside the coast towns is in Greek blockade runners, who will not hesitate to run through the cordon of foreign warships around the island.

There was an exchange of shots on March 20 between insurgents and Moslem volunteers in Suda Bay. The Turkish warships in the bay bombarded the insurgents. The situation of the Turkish garrison in the fort at Malaxa was very critical on March 22. Attempts were made to revictual the fort, but the insurgents rendered the efforts fruitless. If the Christians capture the forts at Malaxa and Keratide, which it now appears highly probable they will do, Canea will be virtually blockaded landward.

Malaxa is within the limits of the Turkish cordon drawn by the admirals of the foreign fleets, but this fact does not prevent the operations of the insurgents within the line, they refusing to recognize the authority of the admirals to establish such a cordon.

A body of Turkish troops who were trying to convey provisions to the fort at Malaxa was held in check throughout the day by the Christian insurgents. The troops, finding that they could not reach the fort, signaled to the gunboats in Suda Bay requesting aid. The gunboats opened fire upon the insurgents, but could not drive them from the positions they occupied, which effectually commanded the approaches to the fort. So far as known, the fire from the warships did no damage.

Admiral Canevaro, the Italian officer who is by reason of seniority in command of the combined fleets of the powers, has issued a proclamation enjoining the insurgents and Greek troops not to attack the Turkish forts at Kissamo, Suda, Malaxa, Retimo, Candia, and Hierapetra, these forts being necessary for the maintenance of order at the ports where the foreign troops will be disembarked. The insurgents at last drove the Turks out of Malaxa and the fleet of the powers opened upon them, but did little damage.

For our engravings of Crete and its inhabitants we are indebted to L'Illustration and Le Monde Illustré and Illustrirte Zeitung.

YOUNG TIGERS AND DOG AT PLAY.

PLAYFULNESS OF YOUNG TIGERS.

It has long been known that tigers may be bred in captivity, though not so easily as the lion, and that they may be tamed when taken young, but their temper cannot be depended upon. Where raised in zoological museums, however, under the eyes of experienced attendants and where the surroundings are most advantageous, they always form a most attractive and interesting feature, of which the public never seems to weary. Our illustration showing young tigers and dog at play has little that suggests the idea that it is a portrayal of one of the most ferocious of wild beasts. It is said that young tigers thus raised in captivity have brighter color and better marked bands than those which grow up wild. Our view is from "The Zoological Garden," J. J. Weber, Leipzig.

THE CATACOMBS OF PARIS.

THOUSANDS of visitors annually go down into the catacombs of Paris, take a walk in the ossuary, and ascend to the light of day, very happy to see the sun again and to no longer have before their eyes that

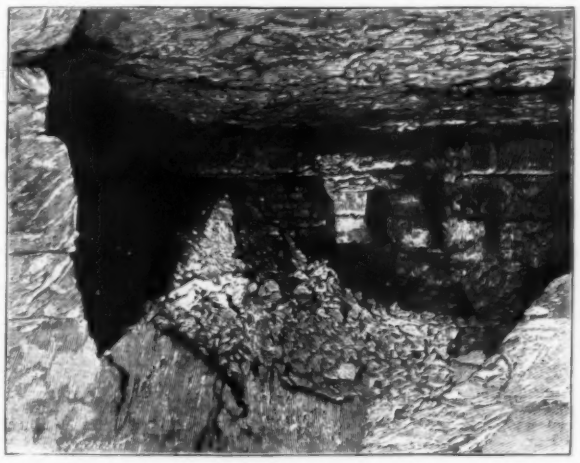


FIG. 1.—INTERIOR OF A QUARRY EXCAVATED IN THE SIXTEENTH CENTURY UNDER TOMBE ISSOIRE STREET.

nightmare of millions of skeletons and grinning skulls which have been removed from their ancient burial place.

Very few of these visitors, however, know what the catacombs are, and what are their origin, extent and future. Scarcely any one is aware of the fact that every year adds a few more miles of galleries to the seventy-five miles of the walled ones that now exist. Yet all this is very interesting, and we are going to try to give a slight idea of it. Let us in the first place go back to the troublous times in which a handful of invaders, following in the wake of Julius Cæsar, fell upon Gaul.

In the place of modern Paris, a humble straggling village of wood stood upon a small island in the Seine; but this, although it had until then sufficed for the needs of our forefathers, was not good enough for the glorious conquerors, who in a few centuries replaced it by a large and beautiful city which, proceeding beyond the island, extended far and wide upon the two shores, taking in to the south Mons Lucotitius (Sainte Genevieve), Mons Fetardus (Mouffetard), and the quarters that have since beenc alled Saint Marcel. Palaces, temples, arenas, and splendid houses of finely dressed stone replaced the humble thatched wooden huts.

Quarries were opened up all around the city to furnish the materials adapted for building purposes, and an inventory taken by architects a very long time afterward, by order of Colbert, teaches us that all the stone employed in these structures was derived from the southern side of the Seine. These quarries, which were at first open, must have soon become subterranean, on account of the greater thickness of the unavailable materials that covered the strata of rock adapted for building purposes, that is, coarse limestone. Thus it is that under the Museum of Natural History, the Quartier Saint Martel and perhaps under the garden of the Luxembourg, we find the chambers and galleries of these first quarrymen as clean as if they had just left them.

Much later on, in the time of the Capetians (the Merovingians having preserved their Germanic custom of building with wood, or having inhabited the remains of the Roman palaces), a new activity reigned in the subsoil of the environs of the city, and all the ecclesiastical edifices of that epoch (Notre Dame, Sainte Chapelle and the hundreds of churches destroyed two centuries ago) came from the subterranean galleries. This mining work continued during the entire period of the middle ages. Every property owner, every church and every convent had a subterranean quarry to himself or itself, and exploited the stone on his or its own account without any concern about the neighbors. (Fig. 1.)

The Carthusian monks mined beneath the site of the present Petit Luxembourg and the School of Pharmacy, and the Capuchins quarried where now stands the Observatory, the Cochin Hospital, a part of the Val-de-Grace, etc. The work was carried on without order and without any regard for the surface of the earth. Sometimes the upper stratum of coarse limestone was exploited and sometimes the lower, so that certain houses happened to rest upon two superposed tunnels, without counting the cellars.

At first the only inconvenience about all this was that it furnished a sure domicile for the numerous robbers and bandits who infested the city and its suburbs at night and held up and levied contributions upon passers-by. The terror that they inspired was great, and the more so in that they were able to introduce into it a little mystery and something of the supernatural by means of some well conceived deviltries, by a few skillfully calculated disappearances under ground at the moment at which they were about to be seized by the archers of the guard, or by the large fires and loud noises at night at the old castle of Vauvert. But Paris was daily growing, and the houses, becoming weightier and weightier, at length caused the subsoil thus undermined to cave in.

The few authors who have treated of the question of the Catacombs carry the first subsidence back only to the year 1774. Thanks to an unpublished manuscript kindly loaned to us by Prof. Gazier, we are able to carry it back still further. Along about 1620, six Feuillantine nuns came from Toulouse in order to establish themselves in the Faubourg Saint Jacques. On September 17, 1625, the first stone of their convent was laid by Cardinal Barberini. Three days afterward, a wall and a huge stone table were swallowed up in a cavity that suddenly opened, and so thoroughly, too, that they could not be found again. A descent was made into the cavity and a plan of it drawn. In 1669 another subsidence occurred. In 1670, a procession took place in the quarries and a statue of the Virgin was placed therein, doubtless the same one that still exists under Saint Jacques Street.

A laborer was buried the same year beneath more than thirty cartloads of stone, but two large rocks having formed a wall beside him, he escaped with a few contusions. "Dom Jean of Sainte Agnes," adds the manuscript, "has remarked and more than two hundred laborers have reported that the ceiling of the quarry cracked wide open in places, whence the laborers had only to make their exit as if the angels had supported the stones until they were in safety."

About the year 1775 several houses of Enfer Gate (Denfert-Rocherean Place) suddenly fell in, then some others, and then others again. The authorities, much alarmed, made soundings and entered the quarries. Soufflot, the architect of the Pantheon, and Brebion were especially commissioned to make an examination, and the not very reassuring report that they published threw Paris into a terror just as great as that which had been occasioned by the bandits of former days.

It was demonstrated that the whole of Paris of that period rested upon immense chasms and that there was not a monument, not a church, not a house, that might not be engulfed all of a sudden. So King Louis XVI

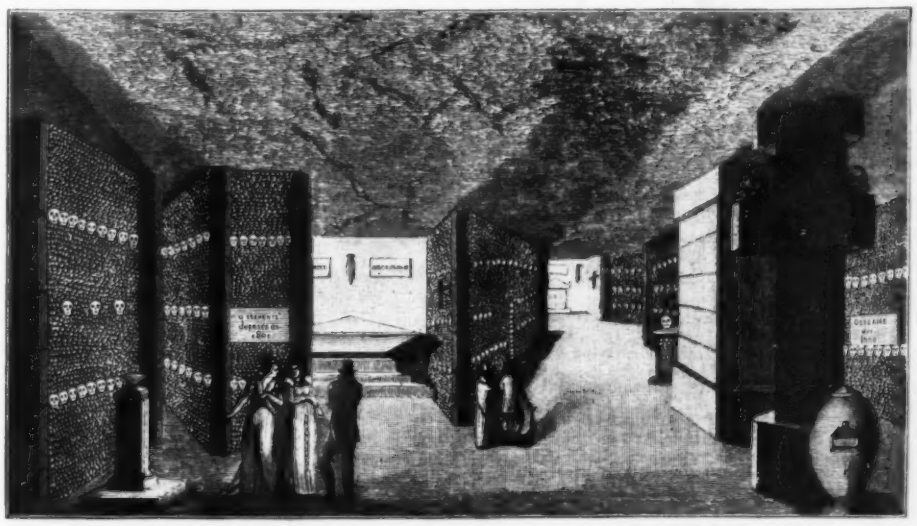


FIG. 2.—A CHAMBER OF THE OSSUARY ESTABLISHED ABOUT 1810 BY DE THURY.

ordered the immediate formation of a technical department of engineers and laborers charged with the duty of inspecting the subsoil and of undertaking the consolidation thereof. Charles Axel Guillaumot was the first organizer of the service (1777). He began the construction of a series of walls and galleries designed to support the roof of the quarries at the points that were most threatened. Hericart de Thury, who succeeded him (1809–1830), constructed true monuments of architecture under ground. The work of these men has since been continued, and more than seventy-five miles of sustaining galleries have been constructed.

The work of consolidating the subsoil of the city is far from being finished, and Mr. Pellé, the present head of the service, is actively occupied with it. After 100 miles more of galleries have been constructed under the present Paris, all the quarries now recognized will have been rendered stable again. But, whatever may be done, the ground of Paris will never again present an absolute security.

It was along toward 1782 that was begun the creation of the ossuary—that vast necropolis which extends beneath the entire quarter of Denfert-Rochereau Place. The crowding of the cemeteries was such that in some of them (the Cemetery of the Innocents, for example) the earth had risen 13 feet above the surrounding streets in a space of 800 years. The cellars of the contiguous houses distilled a true "microbe bouillon," as we would now say, and a simple contact with this sufficed to bring out a rash upon and cause an ulceration of the surface of the skin.

All the bones contained in the ancient cemeteries of Paris were, in measure as the work of demolition proceeded, deposited in appropriate galleries, and all those now taken from the foundations and excavations of Paris find their way to the Catacombs. More than six million skulls are already piled up in the galleries, which have been provided with strong masonry walls and communicate with the general network only by massive iron gates.

Along toward 1780, Buffon, who was then superintendent of the Garden of Plants, undertook to construct some large buildings and was much inconvenienced by the state of the subsoil. "All of our masonry work," wrote he to Thouin in May, 1785, "would proceed well enough except for those cursed quarries, which

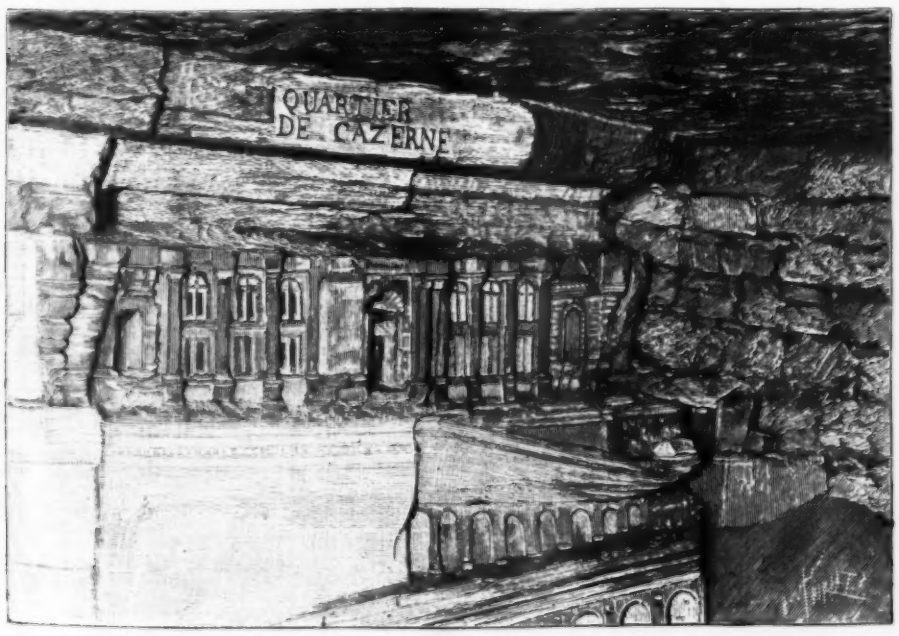


FIG. 3.—THE PORT MAHON SCULPTURE.

alone cost as much as all the rest. Nevertheless, it is necessary to succeed with it, and I have written to Mr. Verniquet (the architect) that, if necessary, we shall further increase the number of laborers for that purpose."

Aside from the funereal decoration of the ossuary, there are a few works of art that enliven certain galleries. Thus, in what is called the Port Mahon quarry, there is observed a series of reliefs that were sculptured toward the year 1780 by a laborer of the quarry inspection and that represent the city and harbor of Port Mahon of the Belearic Islands, where the man, who was named Decure, alias Beausejour, a veteran of the army of Louis XV, had been confined.

In a vault in the lower story, which by its construction recalls the ancient convent crypts, and situated in the environs of Santé Street, are seen three niches, upon one of which is this inscription carved in ancient characters: "Lux" (light), and, upon the two others, in more modern characters, the words "Pain" (bread) and "Viande" (meat).

What was this vault, dungeon or provision storage place intended for? No one doubtless will ever be able to throw light upon the mystery.—Armand Viré, in La Nature.

STORY OF A CELESTIAL WANDERER.*

Those who are not intimately acquainted with the constitution and peculiarities of comets, the celestial wanderers of the sky, have been unnecessarily anxious lately on account of the near approach of Perrine's comet. Vague rumors of dangers from its collision with the earth have been wafted abroad, and numerous letters have been written to learned astronomers, asking if it is really true that the comet will collide with the earth and that the planet on which we live is in danger of destruction. According to Babinet, the chance of an encounter between our earth and a comet will occur on the average once in about 15,000,000 years. Arago said that out of 281,000,000 chances there was only one single chance for a collision. If the nucleus of a comet were equal in mass and solidity to that of Donati's comet, Prof. Faye said that its impact with the earth would develop heat enough to melt and vaporize the hardest rocks. If the comet were composed of small meteoric particles, the result would be a brilliant shower of meteors.

Were the colliding body a hydrogen comet of sufficient size to encompass the entire globe, it might so mingle with the oxygen of our atmosphere as to form such an explosive that the lighting of a single match would produce a mighty flame, which in an instant would consume every living thing on the earth. Still further, since water is the result of burning hydrogen gas in oxygen, this same fierce and terrible flame would be as speedily followed by a mighty deluge of water enveloping the entire surface of our planet. If the body of the comet were not of an inflammable nature, but composed of noxious gases, it would poison our atmosphere, render it unfit for respiration, and thereby entail the most serious consequences. Were it an innoxious gas, owing to its extreme lightness, it would float in and upon our atmosphere as do the clouds, without reaching the surface of our globe. These are the accepted theories of the most eminent astronomers as to the dangers threatening our earth, should we collide with a comet. Nevertheless, it is well to remember that our earth passed right through the train of a comet that appeared in the year 1861, and that the fact only became generally known long after it was all over. The sky was overcast with a peculiar glow, and for a couple of hours that night the earth was actually in the train of the comet, but no one suffered any alarming inconvenience. Sir Robert S. Ball, professor of astronomy at the Cambridge University, England, tells an amusing story of the only disaster known to him arising from the collision. "A clergyman," he wrote, "tells us that at midsummer he was always able in ordinary years to read his sermon at evening service without artificial light. On this particular occasion, however, the sky was overcast with a peculiar glow, while the ordinary light was so much interfered with that the sexton had to provide a pair of candles to enable him to get through the sermon. The expense of those candles was, I believe, the only loss to the earth in consequence of its collision with the comet of 1861." Probably, had the earth passed through the densest part of the comet, that is the nucleus, it might have been a more serious matter.

With regard to Perrine's comet our fears as to the safety of the earth were allayed by the fact that it did not come within 20,000,000 miles of our planet, so that we escaped harm this time!

As to the comet itself, it has been photographed on all possible occasions by A. L. Colton, and a good series of negatives obtained. Cloudy weather interfered when the comet was rapidly growing brighter, and just before it became wholly immersed in the morning twilight. This was unfortunate, as about this time the comet showed signs of increasing activity. A photograph taken December 8 shows a number of flutings in the main tail, with indications of the condensations noticeable in the photographs of some of the recent bright comets. Several short streamers had also appeared in the neighborhood of the two principal tails, projecting backward from the head. These photographs of the comet, while interesting as to detail, would yet be of no value in helping us to identify the comet should it visit our solar system again within a short period of time. As well photograph a cloud or a puff of smoke, for a comet is as variable in its appearance. It may appear at one time adorned with a glittering raiment extending millions of miles in space, and at its next return it may present the appearance of a comet without any train at all. Even while we are observing a comet from day to day, it will change rapidly in appearance, as, for instance, Donati's comet, seen in the year 1858. However, it is possible to recognize a comet on its return to the solar system by means of the well marked path along which it travels. But even this may fail us, for if disturbed by heavenly objects which it may meet on its way, it is driven so completely out of its road that it is compelled to make a new path for itself. This actually occurred in the case of Lexell's comet, seen in the year 1774, and which approached too near to the giant planet Jupiter. As for Biela's comet, its experience was even more trying, and it is now known as the lost comet. It is undoubtedly missing, and its tragic story is a gloomy page in the annals of comet history. It was first observed on February 27, 1826, by an Austrian officer named Biela, and it was then a small comet, some 40,000 miles in diameter, and sometimes showing a short tail. It had a period of 6·6 years, and its path came within a few thousand miles of the earth's orbit, the approach sometimes being so close that a collision was imminent, should the comet and the earth happen to arrive at the same time. In 1832 the comet had terrified the people, because astronomers had announced that it would cross the earth's path. Persons of weak mind died of fright, and others made their wills, thinking the end of the world was at hand! However, the earth missed the comet by one month that time, and we escaped a collision. The comet, apparently, was not quite so fortunate, while hurrying through space, for some unknown disaster must have occurred, causing it to split in two. When it made its appearance in 1846, in place of one comet, two were seen traveling side by side, with a gradually increasing distance between them, and with a singular interchange of light, now one and now the other being the brighter. In 1852 the comet again returned to our neighborhood, the companion comets being more than a million miles apart, and since then neither of them has ever been seen again. What dangers may it not have experienced!

In the opinions of the great astronomer, the younger Herschel, who, writing in 1866, when the comet was first missed, said: "Peradventure it has plunged into and got bewildered among the rings of meteorolites." When we remember the labyrinthine meteor systems in the near neighborhood of the sun, through which the comet had to plow its way, it is no wonder that it lost its head in the most literal sense of the word. In fact, from all that we know of the structure of a comet's head, we must realize that minute and scattered as are the meteors comprising such rings, they are quite sufficiently compact to effect the destruction of a comet dashing headlong, and at an enormous rate of speed, into their midst. There remains, however, another chapter in the history of the missing comet. In 1872, on November 27, just as the earth was crossing the track of the lost comet, but some thousands of miles behind the place where the comet ought to be, it encountered a wonderful meteoric shower. It is not certain whether these meteors were the remains of the comet itself, but as a similar meteoric shower occurred in 1885, when the earth once more crossed the track of the comet, we cannot help drawing our own conclusions from this remarkable coincidence. Comets then die, as Kepler wrote years ago, and their materials actually become, in smaller or larger proportions, part of our globe.

It is interesting to trace the career of a comet, from the time when each separate meteoric particle contained in it was once a solitary wanderer in space until, encountering other meteors on its way, they banded together, forming an army of celestial wanderers. The head or nucleus of the comet grew larger and larger until, puffed up with hydrogen and vanity, it longed to venture into the realms of King Sun. The intense heat of the solar surroundings drove myriads of meteors away from the nucleus of the comet. A train was thus formed millions of miles in length, and the comet gloried in its glittering raiment. But, alas! as it withdrew from the neighborhood of the sun, it not only became chilled in the depths of space, but it was unable to recall the deserters that had once followed in its train. After many such visits to the sun the comet declined in size and magnificence, until at last it presented the sad spectacle of a comet without any train at all. But Biela's unfortunate comet went even one step further, going out of existence altogether. It first made its appearance like any well regulated comet, as an army of celestial wanderers journeying together through space, and it finally made its disappearance amid a glorious display of meteors. Thus perished this celestial wanderer 'mid a "flash of glory," as befitted an inhabitant of the star depths.

* By Mary Proctor, in our excellent contemporary Popular Science News.

THE PROBLEM OF INSTINCT.*

By Alfred R. Wallace.

There is probably no subject in the whole range of biology the study of which has been so universally neglected as instinct. Both scientific and popular writers continually refer to it as if its nature and limitations were matter of common knowledge, and its facts so well established as to be almost above criticism. Yet when we ask how it is known that certain actions of man or animals are due to instinct and not to experience or imitation, we find an almost total absence of accurate observation or experiment, while hardly two writers are agreed as to the exact meaning of the term. It is only within the last quarter of a century that a few biologists have made any careful experiments on the phenomena presented by the actions of the higher animals, under such conditions as entirely to exclude the agency of imitation or of parental guidance; and although these experiments are as yet quite insufficient in quantity and far too limited in scope, having regard to the wide field covered by the actions and behavior usually considered to be instinctive, yet the results reached are already very interesting, and are sufficient to show us that we need not despair of a complete solution of the problem, at all events as regards the higher animals.

One of the first English observers to attack the problem on the experimental method was the late Mr. Douglas Spalding, who in 1873, in Macmillan's Magazine, described a number of experiments on young chicks and ducklings, carefully blinded for the first few hours after birth. His conclusions were, that these young birds not only showed intuitive powers of walking, scratching, and pecking, but also possessed intuitive knowledge—or acted as if they possessed such knowledge—of various kinds. He asserted that they were afraid of bees and of the cry of a hawk, and that they intuitively knew the meaning of a hen's call note and danger signal when heard for the first time. These results were opposed to Mr. Spalding's preconceived ideas, and were therefore the more readily accepted, and have been frequently quoted as settling this point—the possession of instinctive knowledge as well as the power of co-ordinated movements of various kinds. Now, Professor Lloyd Morgan has repeated all these experiments many times and with a considerable variety of species, and while confirming many of Mr. Spalding's observations and conclusions, has shown that those here referred to are erroneous. More important still, he has shown exactly where and why the conclusions arrived at are erroneous, and has thus afforded most valuable guidance to future experimenters in this interesting inquiry. Some examples of these corrections are the following.

Mr. Spalding noticed a difference in the behavior of young chicks to flies and to bees, and concluded that they "gave evidence of instinctive fear of these sting-bearing insects." This, if true, would be very important, since it would show an intuitive perception of the dangerous character of a special insect, and if of one, presumably of all common dangerous or hurtful objects, antecedent to experience. But the whole series of observations made by Professor Morgan himself, as well as those made by other good observers, shows that they have no such perception of the qualities of objects. They pick up stones as well as grain, bits of red worsted as well as worms, gaudy-colored inedible caterpillars as well as those which are edible. They do not recognize water till they have felt it, and they do not know that water is drinkable till contact with the beak sets up the nervous and muscular reactions of drinking. By a series of careful experiments Professor Lloyd Morgan shows that young chicks have no fear of bees as bees, but merely because they are large and unusual. They are equally suspicious of a large fly or beetle, and, though eating small worms greedily, are afraid of a large one. And when the chicks were a few days old, and were no longer afraid of large flies, they showed no fear even of wasps, when presented to them for the first time.

Very similar is the correction of Spalding's statements that his young chicks gave the danger signal when a hawk was flying high overhead, and that a young turkey showed equal alarm when a young hawk, kept in a cupboard, uttered a shrill sound; whence he concluded that the fear of birds of prey, whether seen or heard, was instinctive. For it is now shown that any strange object or any unusual sound causes exactly similar alarm when first seen or heard by any kind of young birds, and Mr. Hudson, of La Plata fame, came to a similar conclusion. Other cases which have been thought to prove instinctive dread of enemies in various young animals are shown to be explicable on similar principles; any sight, or sound, or smell, very different from what they have been accustomed to, alarms them, and they learn what are really dangerous either through the actions of their parents or by their own personal experience.

But, though young birds and mammals do not possess instincts which enable them to discriminate between objects that may be useful and those that may be hurtful to them, they often possess the most wonderful acuteness of the senses and powers of co-ordinated muscular action, which enable them rapidly to acquire the knowledge that is essential to them. The young chick only a few hours out of the shell walks and runs, and is able to pick up small objects in its beak, some being rejected and others swallowed. The young duck swims when put into the water, or when it accidentally walks into it, but it has no instinctive desire for it, and does not, as is often stated, run to it from a distance. Young dippers dive perfectly the first time they reach the water, and young swallows fly with great precision, avoiding obstacles almost as readily as do the old birds. With such congenital powers, and with an instinctive fear or suspicion of everything that is strange to them, they learn with marvelous rapidity; and having once found that a particular object is disagreeable or unfit for food, they rarely require a second lesson, and thus in a few days accumulate a stock of experience which, unless the process has been closely watched, may easily be set down to instinct.

About one-third part of Professor Lloyd Morgan's work is devoted to such experiments and observations on young birds and mammals as have now been indicated, and the amount of new and varied information here brought together is sufficiently large to form the basis of sound reasoning on the nature and limitations of the faculties involved; and perhaps no living biologist is better fitted to do this successfully than the author. In the series of chapters headed: "The Relation of Consciousness to Instinctive Behavior," "Intelligence and the Acquisition of Habits," "Imitation," and "The Emotions in Relation to Instinct," we have a careful and interesting study of the physiological and psychological aspects of the facts that have been laid before us; a study which is in the highest degree instructive, and which will serve to guide future students of the subject both as to the interpretation of the facts already established and as to the observations most needed for the elucidation of matters which are still unsettled. These chapters, however, are hardly suited for illustration or summary, and we will therefore pass on to those which deal with the alleged instincts of adult animals, and with some of the most disputed questions which now divide biologists; but, before doing so, it will be well to quote the author's definition of instinct, as well as the conclusions he has reached as to its nature.

At the end of the first chapter, which gives a popular sketch of the facts which demand explanation or verification, Professor Morgan says:

"We may now sum up what has been advanced in the foregoing discussion, and say that, from the biological point of view, instincts are congenital, adaptive, and co-ordinated activities of relative complexity, and involving the behavior of the organism as a whole. They are not characteristic of individuals as such, but are similarly performed by all like members of the same more or less restricted group, under circumstances which are either of frequent recurrence or are vitally essential to the continuance of the race. . . . They are to be distinguished from habits which owe their definiteness to individual acquisition and the repetition of individual performance."

And after having described the various actions of young birds antecedent to experience, our author summarizes some of the conclusions to be drawn from the observations as follows:

"1. That which is congenitally definite as instinctive behavior is essentially a motor response or train of

* Habit and Instinct, by C. Lloyd Morgan, F.G.S. London: Edward Arnold, 1896.—From Natural Science.

motor responses. Mr. Herbert Spencer's description of instinct as compound reflex action is thus justified.

"2. These often show very accurate and nicely adjusted congenital or hereditary co-ordinations.

"3. They are evoked by stimuli, the general type of which is fairly definite, and may, in some cases, be in response to particular objects. Of the latter possibility we have, however, but little satisfactory evidence.

"4. There does not seem to be any convincing evidence of inherited ideas or knowledge (as the term is popularly used); that is to say, the facts can be equally well explained on the view that what is inherited is of the nature of an organic response.

"5. Association of ideas is strong, and is rapidly formed as the result of individual acquisition.

"6. Acquired definiteness is built, through association, on the foundation of congenital responses, which are modified, under experience, to meet new circumstances.

"7. Acquired definiteness may pass, through frequent repetition, into more or less stereotyped habit."

Having thus given the author's standpoint and his main conclusions from a body of well-observed facts, we will pass on to his treatment of those activities of adult animals which are generally classed as instinctive.

In the chapter on "Some Habits and Instincts of the Pairing Season," the songs, dances, and displays of plumage by birds are described, and Professor Lloyd Morgan seems inclined to the conclusion that their great development indicates the action of that form of sexual selection termed "preferential mating." Some additional observations are quoted which support this view, but the final conclusion is that—"in all these matters further and fuller evidence from direct observation is to be desired."

The next chapter is on "Nest Building, Incubation, and Migration," and affords much matter for careful consideration. As to nest building, I have always urged that careful experiments are required before we can accept as instinctive the building of a peculiar type of nest by each species of bird; and we find a few such recent experiments now adduced. But when we remember how such a careful experimenter as Spalding was led to wrong conclusions through not varying his experiments sufficiently, the few experiments yet made on nest building under conditions by no means rigid and with results not described in sufficient detail, can hardly be accepted as settling the question. This is one of the problems that can only be finally settled by experiments tried on a large scale and with every precaution, and the results preserved for comparison and study; and if ever an experimental biological farm is established, this subject of nidification would form one of its most interesting and comparatively easy inquiries.

Passing over a very interesting discussion as to the habits of the cuckoo and their probable origin, and one hardly less interesting on the habit of the lapwing and many other birds of simulating injury to distract attention from nest or young, we pass on to the broader and more important subject of migration, which, however, is rather briefly treated. The evidence now accumulated seems to justify Professor Lloyd Morgan's conclusion, that while the migratory impulse is innate, yet, "the element of traditional guidance may be effectual, in the migration stream as a whole, in some way that we have hitherto been unable to observe." The chief obstacle to this view consists in the well known observations of Herr Gätke at Heligoland, that, during the autumn migration, in the case of the great majority of species, the young birds migrate earliest and alone, the adults following considerably later. But admitting, as everyone must, the accuracy of Herr Gätke's observations, does the conclusion necessarily follow? He himself assures us that the birds which rest on or pass within sight of Heligoland only form a fraction of the whole of the migrating hordes, most of them traveling by night at great altitudes, and very few passing within sight of the island, and of these few only, perhaps, one in ten thousand stopping to rest. The fact that young birds of many species are the first to visit Heligoland every year without exception, may possibly be explained by the fact that, while the older birds which lead the way travel high and go on without stopping, a large number of the young fly lower, and being either fatigued by the long, unaccustomed flight or attracted by the sight of the land, descend to this elevated and fertile islet for rest and food. The late Mr. Seebohm, whose extensive journeys to Siberia and in various parts of Europe for the purpose of collecting and studying birds rendered him an authority on this subject, gives the early migration of young birds on the authority of the Heligoland observers, and does not support it by any observation of his own in the northern regions from which so many of the migrants come. In America, although some writers state that young birds migrate first in autumn, Mr. C. Hart Merriam, of the Department of Agriculture, tells us that this notion is "contrary to the experience of most leading American ornithologists and to the information collected by the Committee on Migration of the American Ornithologists' Union."* But if we reject the conclusion based upon the Heligoland facts as not necessarily following from them, we shall find that there is not much difficulty in forming a theory which accounts for the main phenomena, and the outlines of such a theory have been very well expressed by Mr. Seebohm himself at the end of the chapter on migration in his "Geographical Distribution of the Charadriidæ," in the following passage:

"The assemblage of migratory birds in large flocks, which in many cases wait for a favorable wind before they venture to cross wide stretches of sea, and consequently start all together as soon as the weather is suitable, and arrive on the other side in enormous numbers or rushes; the keen sight of birds and their extraordinary memory for locality; the great variety of routes chosen, and the pertinacity with which each species keeps to its own route—these and many other facts all point in one direction. The desire to migrate is a hereditary impulse, to which the descendants of migratory birds are subject in spring and autumn, which has acquired a force almost, if not quite, as irresistible as the hereditary impulse to breed in the spring. On the other hand, the routes of migration have to be learned by individual experience. The theory that the knowledge of when and where to migrate is a mysterious gift of nature, the miraculous quality of which is attempted to be concealed under the semi-scientific term of instinct, is no longer tenable."

The views here expressed appear to me to harmonize well with the general conclusions as to the nature and limitations of instinct arrived at by Professor Lloyd Morgan, and they are enforced by some considerations which writers on this subject usually overlook. The numerous recorded facts of birds returning year after year to build in the same spots as in the preceding year indicate that most of the spring migrants are old birds. Not only is this the general belief of observers, but it is rendered probable by the known longevity of most birds, and the obvious circumstance that those which have escaped the dangers of the double migration on the first occasion will be more likely to escape in each succeeding year, so long as health and strength continue. The fact that the breeding population of birds in any country does not increase year by year, but, though there are considerable fluctuations, remains on the average constant, proves that there must be an enormous destruction of the young birds, which certainly amount in number to several times as many as the old ones, and it seems probable that this destruction takes place during the two annual migrations, and more especially during the first one in autumn, when the young birds have had no practice in long continued flight and no experience of the dangers of the sea. If the birds of more than one season live on the average only four or five years more, it follows that only a very small percentage of the enormous annual progeny of young birds can survive to take their place. Hence it may well be that all those countless myriads of birds of the year that visit Heligoland are among the failures which, if they leave the island, perish in the waters. We know that enormous numbers must perish during each year, and where so likely as during that first attempt to traverse the North Sea? This is rendered almost certain by the recently issued Report of the British Association Committee on Bird Migration, in which it is stated that at the various periods of the great autumnal rushes at Heligoland, when countless thousands of birds pass over that island, no corresponding influx has been noticed on our east coasts during the four successive years that the two records have been compared. Either then, these myriads of birds passed southward to Holland or flew out to sea and were mostly lost. As Herr Gätke does not mention any corresponding flights along the coasts of Holland and Belgium, it is to be presumedt hat they have not been noticed, and we are almost forced to the conclusion that the greater part of these young birds, whose immense numbers at Heligoland excite so much astonishment, are really failures, and form a portion of those which are annually eliminated by the severe test of migration; and if this be so, much of the marvel supposed to attach to the successful migration of young birds disappears, since such "successful migration," except in the case of a small percentage, does not occur.

There is one alleged instinct of great popular interest Mr. Lloyd Morgan does not deal with—the means by which many of our domestic animals, especially cats, dogs, and horses, find their way home under circumstances which seem to preclude any direct guidance by the senses. Narratives of the most marvelous character have been published, but, unfortunately, no systematic experiments appear to have been made, except a few by the late Mr. Romanes. These showed that a dog could exactly track its master's footsteps by scent, and it was shown that the scent was derived from his shoes, which must of course be full of perspiration and other emanations from the skin, because when he wore new shoes or those of another person his track could not be followed. In Nature, vol. vii, there is a considerable discussion of this subject, and many remarkable cases are narrated by various correspondents, but in none are all the data given for arriving at a rational conclusion on the question. I then wrote summarizing the discussion (Nature, vol. viii. p. 65), and suggested a series of experiments, which would alone give us any real information. My suggestion was that a dog whose antecedents were known should be taken by a circuitous route by rail and road to some spot where he had never been before, and should be there handed to some person he did not know, who should carry him a short distance, and on releasing him should keep him in sight, either on foot or horseback, till the animal had returned home, noting carefully every movement and action. A moderate number of such experiments would settle the question of instinct or sense observation, and it is to be hoped, now that a more intelligent interest is taken in the subject, such experiments will be made.

I may add that, theoretically, any instinct of direction is almost inconceivable, because quadrupeds in a state of nature do not require such an instinct. They learn, step by step, the surroundings of their birthplace, extending their range, perhaps, year by year, but never requiring to go back over a country they have not previously traversed. In their case ordinary memory, assisted by very acute senses, would be all they would need. In the case of domestic animals returning home, we find that the recorded time elapsed varies from a few hours to several days or weeks, even when the distance can be easily traversed in a day. This shows that an instinctive sense of direction cannot always be the agency employed; and, as in no one case is the exact route of the animal's return known, the assertion so often made, that a special sense of direction is required to explain the facts, cannot be justified.

Two very interesting chapters, near the end of the volume, are those entitled "Are Acquired Characters Inherited?" and "Modification and Variation." In the first of these the bearing of the whole of the phenomena of instinct on the vexed question of inheritance is pointed out, and the conclusion is reached that, although there is little or no satisfactory evidence of the transmission of acquired modifications—that is, of habits, or their effects on the organism, as opposed to instincts—yet there are many curious facts which seem to indicate some connection between congenital and acquired characters. What this connection is, the chapter on modification and variation attempts to show.

Modification of the individual by the environment, whether in the direction of structure or of habits, is universal and of considerable amount, and it is almost always, under the conditions, a beneficial modification. But every kind of beneficial modification is also being constantly effected through variation and natural selection, so that the beautifully perfect adaptations we see in nature are the result of a double process, being partly congenital, partly acquired. Acquired modification thus helps on congenital change by giving time for the necessary variations in many directions to be selected, and we have here another answer to the supposed difficulty as to the necessity of many coincident variations in order to bring about any effective advance of the organism. In one year favorable variations of one kind are selected and individual modifications in other directions enable them to be utilized. In Prof. Lloyd Morgan's words:

"Modification, as such, is not inherited, but is the condition under which congenital variations are favored and given time to get a hold on the organism, and are thus enabled by degrees to reach the fully adaptive level."

The same result will be produced by Prof. Weismann's recent suggestion of "germinal selection," so that it now appears as if all the theoretical objections to the "adequacy of natural selection" have been theoretically answered.

Biologists owe a debt of gratitude to Prof. Lloyd Morgan for this most interesting and suggestive volume. It exhibits all the clearness and philosophical acumen which characterize the writings of the author, and although in his desire to be impartial he has sometimes suggested difficulties which are more apparent than real, yet the work is on the whole an admirable introduction to the study of a most important and fascinating branch of biology, now for the first time based upon a substantial foundation of carefully observed facts and logical induction from them.

* Report on Bird Migration in the Mississippi Valley, by W. W. Cooke, p. 13, foot note.

THE BACTERIOLOGY OF MILK.

PROF. CONN, of the Western University, has recently presented, in a report published by the United States Department of Agriculture, a summary of observations in relation to the bacteriology of milk.

Pure milk, as has long been known, drawn from a healthy cow, with proper precautions, contains no bacteria, but under ordinary conditions milk becomes infected with great numbers of microbes, which grow with astonishing rapidity. Prof. Conn found that the milk obtained at Middletown, Conn., contained, within two or three hours after being drawn, from 330,000 to 9,000,000 microbes per ounce. The milk supply of Boston was found to be infected to a much greater degree, as many as 135,000,000 germs being found per ounce in some specimens. The milk of Madison, Wis., during the months of May and June, was found to contain 60,000,000 microbes per ounce.

The milk supply of European cities has been found infected to a much higher degree, the number of microbes being rarely less than 150,000,000 germs per ounce, and often reaching as high as 600,000,000, and sometimes the enormous number of 5,400,000,000 in a single ounce.

The number of different kinds of microbes found varies from a half dozen or more to as many as fifty in a single locality. One German investigator found sixty-nine different kinds of microbes in a series of cheeses. These germs give rise to the so-called "ripening" of cheese, as it has been found that cheese cannot be made from boiled or sterilized milk. It is thus evident that "ripening" as applied to cheese is simply another name for decaying. The germs of tuberculosis, diphtheria, and typhoid fever are not infrequently found in milk.—Modern Medicine.

TETRA-NITRO-CELLULOSE—A NEW EXPLOSIVE.

By H. N. WARREN, Principal Liverpool Research Laboratory.

WHEN dinitro-cellulose, or ordinary soluble pyroxylin, is further acted upon by means of a mixture composed of equal parts by volume of nitric acid 1·5 density and concentrated sulphuric acid, there is, as is well known, produced a true trinitro compound, differing entirely from either of the above compounds as regards its solubility, and at the same time possessing far enhanced explosive properties.

If the resulting compound thus formed is again treated with a still more energetic dehydrating agent, composed of equal parts by weight of commercial vitriol and phosphoric anhydride, a further nitrogenous compound is obtained, which, after the usual washing and drying, presents a much more brittle structure than any of the preceding derivatives, in some cases even admitting of pulverization, and altogether a much more formidable compound, even exploding by mere percussion, its explosive violence as compared with the former bodies being more than double.

When the compound is digested in a strong solution of potassium chlorate, and carefully dried, it is rendered extremely brittle, and thus readily admits of being pulverized, forming a true percussion agent. As far as can at present be ascertained, the new explosive represents a tetra-nitro compound; but owing to its formidable explosive properties, necessitating considerable care in handling the same, further investigations are considered necessary in order to arrive at a correct formula. The compound, when submitted to destructive distillation, in contact with moist caustic potash, evolves hydrogen gas, together with large quantities of methylic alcohol.—Chemical News.

IN an article entitled "Made in Japan," The Pall Mall Gazette describes how manufacturing nations have always encroached upon each other's domains. The Dutch, importing English clay, made good profit out of imitations of Chinese porcelain, and after a while the Dutch product became firmly established in the markets of the world as Delft ware. English potters copied the Dutch pattern, sold it a good deal cheaper, and the North of England became the headquarters for Delft china. Lately the Japanese, having acquainted themselves with the patterns best liked in England, encroach upon the domain long monopolized by the English potter. The Japanese product is much finer and stronger, and above all much cheaper than the best English ware, and thus Japan is providing the markets with goods which were originally regarded as a Chinese monopoly.

A SINGLE RAIL RAILWAY.

THE name of Mr. Decauville is associated everywhere with railways of the lightest possible class, and especially with portable railways, which have found so large a use in agricultural districts in many parts of the world. In its fullest development no better illustration of the Decauville system can be found than that which offered such great facility to visitors at the Paris Universal Exhibition of 1889. Since that date the use of the Decauville system has been constantly on the increase, and in England more than one manufacturer, following the same lines, has found ample occupation and profit in constructions of this nature. Other inventors less practical than Mr. Decauville have from time to time sought by the introduction of useless and cumbrous complications to simplify his already elementary system, and by the use of one rail only. But however cheap relatively, and certainly efficient, the Decauville system is, there are many occasions in which the amount of traffic does not justify the purchase of even the lightest types of this system, and yet where at the same time through scarcity of labor and badness of roads some assistance to horse or manual traction would make all the difference to the success or failure of the agriculturist, and which would prove an advantageous and profitable means of communication between remote places where a certain amount of traffic exists without any cheap means of accommodating it.

FIG. 1.

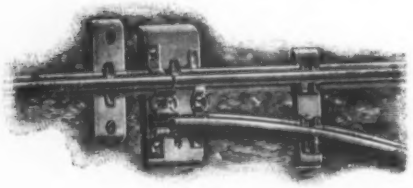


FIG. 2.

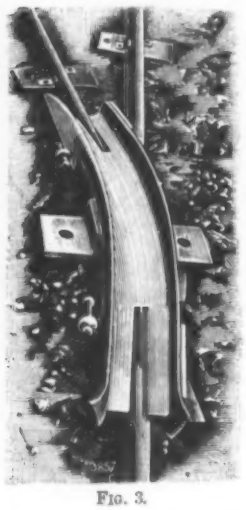


FIG. 3.

RAILS OF THE SINGLE RAIL RAILWAY.

Such a demand appears to have been met in a most ingenious fashion by a French engineer, Mr. Cailletet, who has devised a real mono-rail system, either portable or permanent, and which, though it is not applicable to steam or other power traction, does nevertheless, in the simplest manner, possess the conditions demanded for limited traffic in sparsely populated districts, and especially for colonial agriculturists.

The permanent way of this system consists of a single flat-footed rail of very light section, to which are attached at short intervals flat soleplates or sleepers, in each side of which holes are formed for the passage of a pin that can be driven into the ground to hold them in place; the rail joints are made by fishplates surrounding the base of the rail, the whole arrangement being clearly illustrated by Fig. 1. The vehicles running upon this rail are of various forms, according to the service for which they are required; they may be flat platform wagons or small omnibuses, ambulances or box wagons. The illustrations given herewith illustrate a certain number of these varieties. For the most part they are supported on four wheels, the tires of which are grooved to fit the contour of the rail; these wheels, which run in bearings on the underframe of the vehicle, may either extend beyond it at each end or be placed beneath the body of the carriage. It is needless to say the wheels are all in the same plane. Obviously such a vehicle, especially when loaded, could not be maintained in equilibrium, and it is in overcoming this difficulty that the ingenuity of Mr. Cailletet is conspicuous. Projecting from one side of the vehicle, as will be seen from the illustrations, are two rods, or a light frame, the former being required when only manual labor is employed, the latter when horse power is used for propelling the vehicle. Assuming that the carriage could be so accurately loaded that its balance upon the rail would be perfect, it is clear that no effort, except that required for propelling the carriage, would have to be exerted either by men or animals; but although this is practically impossible, the load can nevertheless be so evenly distributed as to call for but a small effort to overcome the tendency to fall in either direction, so that practically the only work that has to be done is that due to overcoming tractive resistances, which are insignificant upon the rail as compared with those upon a road or the uneven surface of a cultivated field. It should be mentioned that no difficulty occurs in loading the vehicle, because until they are ready for transport, supports hinged to the outstanding frame are detached and placed upon the ground so as to make the wagon quite stable.

This ingenious system is so simple that no further description is necessary to make it clearly understood, especially with the aid of the illustrations which we publish. But since it has already found a useful and extensive application in France and her colonies, and should come into extensive use with ourselves, it will be of interest to give some information regarding the actual details as they have been worked out. The rail employed is a very light section, and is supported on the ground by the numerous bedplates already referred to; it is of the Vignolles type, and up to the present time is used in four different weights, according to the nature of the service required; these are 4½, 7, 9½ and 12 kilogrammes per meter (3, 4·7, 6·4 and 8 lb. per foot). For portable lines, for which the greatest application is found, the permanent way is usually laid in sections of 5 meters, and such a section, consisting of the rail, six bedplates and the fishplate, projecting from the end of the section, weighs either 27·700, 40·300, 42·900, 55·950, 62·100 or 75 kilogrammes, according to the type which is best suited for the lighter or heavier traffic that may be required. In the lighter types the weight is sufficiently small to allow of a section being carried by one man. The permanent way is entirely of steel, and the rails are not weakened by being drilled, the fishplates being of a special type, designed to hold the rails without bolts. The rails are made in lengths of 2.50 meters and 1.25 meters for convenience of laying. The bedplates are rectangular, with stiffening flanges on all four sides, and the length varies from 20 to 30 centimeters, the width being from 10 to 20 centimeters, according to the weight of the rail employed. As will be seen from Fig. 2, two brackets are riveted to the bedplate, of such a form as to permit the passage of the foot of the rail. These brackets are placed diagonally on the baseplate, and after the rail has been passed through, it is pulled back, so that the brackets lock upon it, and hold it firmly, in such a way that the center of the baseplate coincides with that of the rail. Where the rail is laid over very soft ground, the foundation can be improved by previously putting down fascines, etc. The end bedplates of each section are placed so as to allow the rails to project about 30 in; over these ends the fishplate, which is made of steel and somewhat elastic, is slipped, as shown in the illustration. The end of the fishplate projects beyond the rail, so that the end of the next section can be sprung into it, and when in place it abuts upon and is held fast by the two end baseplates. The sharpest curves which are used upon this system are of 4 meters (13 ft.) radius, but this is inconveniently small, and causes considerable friction, so that a radius of 8 meters (26 ft.) is regarded as the standard minimum curve, and bent sections of permanent way are provided as part of the equipment to suit this or any other desired curvature. Naturally switches are required for turning the vehicles on to sidings or branches, and these, like all the rest of the system, are of an extremely simple character; at first they consisted of a cast plate with double inclined planes, Fig. 3, by means of which the carriage was run off the rails on to the surface of the ground and then up on the rail of the branch; another device is now employed by the inventor. The means of changing the direction consist of a metal plate to which are fixed the ends of two or three rails forming the commencement of as many branches; by means of a lever the end of the fixed rail can be moved to the right or left suffi-

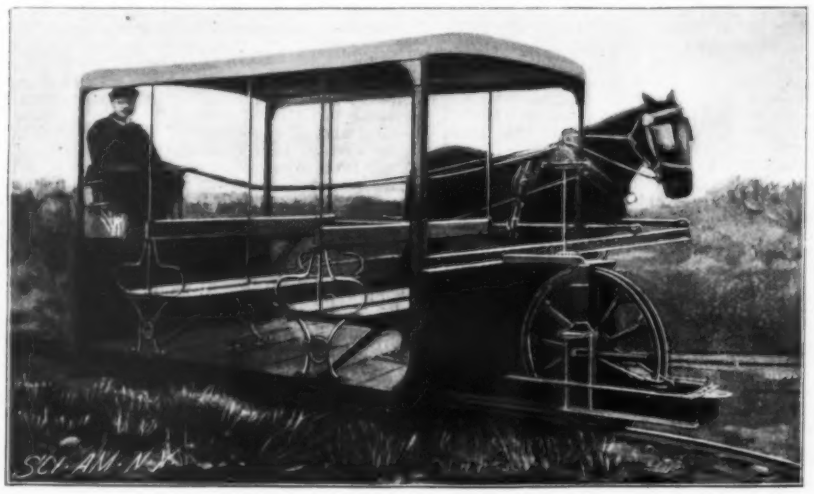


FIG. 4.—SINGLE RAIL PASSENGER CARRIAGE.

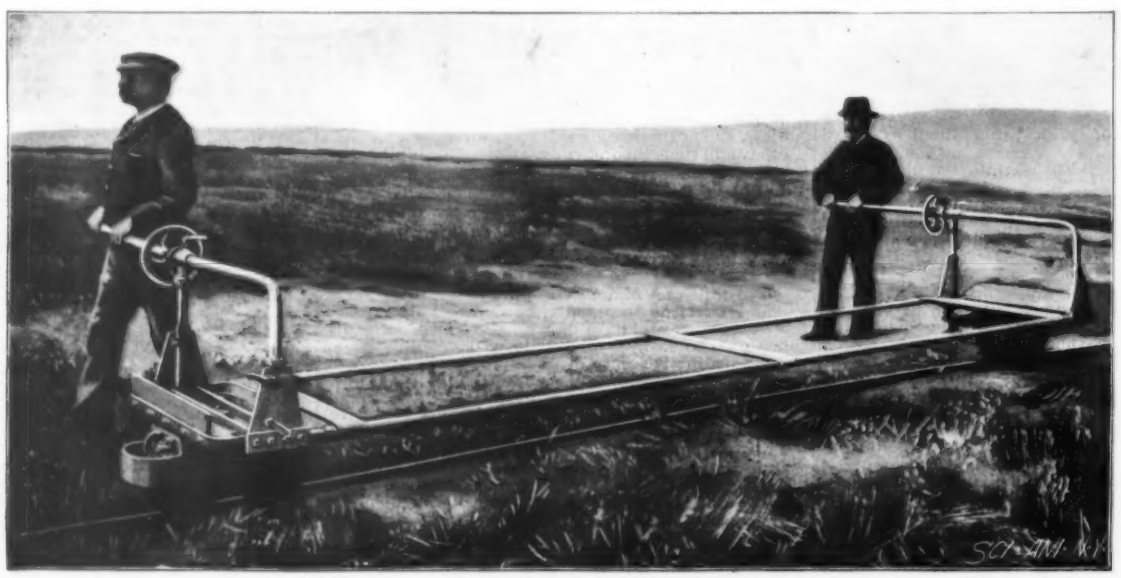


FIG. 5.—OPEN FRAMED HAND CAR.

ciently to coincide with one or other of the branches; for crossings, plates of an equally simple character are employed.

The rolling stock of the Cailletet single rail railway may be propelled either by hand or animal power, the vehicles of the former class being of course much lighter than those of the latter. An ordinary type of hand vehicle is adapted to carry a load of about 700 lb., and is mounted on wheels 10 in. in diameter. There is, however, a large variety of types in use, the smallest of which is the wheelbarrow. It consists of a low box body with wheels projecting at each end, and loose girder frames in which the wheels are mounted; these wheels are controlled by brakes, and to the car body are secured the light tubes which serve as traction bars.

The system Cailletet has already found a considerable number of applications, as, for example, for earth wagons, where two bodies can be mounted on one frame; these can either be propelled by hand or horse power. As will be seen, the method of harnessing is very simple, and there is never any occasion to turn the vehicle, as the horse can be attached indifferently for one direction or the other. Figs. 6 and 7 illustrate

FIG. 6.—HORSE-DRIVEN SINGLE RAIL CAR.

sides to facilitate unloading. A number of special forms of this elementary class of vehicle have been constructed to suit special requirements, chiefly for colonial work. A larger form of hand-propelled wagon is that illustrated by Fig. 5, which is specially adapted for the transport of forage, sugar cane, etc. The ambulance car is a very interesting adaptation which has also been used in the colonies; it is an ambulance car with a very light frame covered with cloth and provided with curtains on one side. It contains two stretchers, which are suspended by loops attached to the frame, and which can easily be removed or fixed in position. Other examples include trucks specially adapted for moving heavy objects, such as bridge girders, telegraph poles, trees, etc. These are provided with two traction bars, and it is necessary to have two men to propel them and to keep the vehicle in equilibrium; each of these bars, as shown in the engraving (Fig. 5), is provided with a handwheel controlling a brake which operates on each of the trucks. It may be mentioned that the outside width of vehicles of this type is about 5 ft. For rolling stock of a heavier class moved by animal power, it is necessary to have a total width of nearly 10 ft. Such wagons are constructed on the same general principles as the lighter ones worked by hand, but they are, of course, heavier and of much greater capacity, being able to carry one or two tons. They are mounted on wheels from 20 in. to 30 in. in diameter, the general arrangement being, in all cases, the same. From the illustrations it will be seen that the body of the car is carried on two light

FIG. 7.—HORSE-DRIVEN TILTING HOPPER CAR.

which could be worked more successfully by the Cailletet mono-rail tram system than by any system of motor cars of light narrow gage railway. For our engravings and the foregoing particulars, we are indebted to Engineering.

AN accidental firing of an artesian well at Hempstead, Texas, disclosed the fact that the water had tapped a vein of natural gas.

WATT AND THE MEASUREMENT OF POWER.*

By WILLIAM HENRY PREECE, C.B., F.R.S.

JAMES WATT, who died seventy-seven years ago, was a great inventor. He was "one of the most illustrious followers of science, and one of the greatest benefactors of the world." If he had never improved the "fire engine" of his, the "steam engine" of our day, the copying press alone would have maintained his name on the scroll of inventive fame. His greatest invention—that which has been most prolific in exciting further improvements in the steam engine, and which has supplied the engineer with a new sense—is perhaps the "indicator."

The indicator enables an engine itself to record automatically on paper a diagram which, properly interpreted at leisure, conveys a clear history of the performance of the steam in the cylinder. It enables the engineer to measure the actual work that is being done by it, and it gives a report of the action of the valves and parts which control the ingress and egress of that steam, and which regulate the performance of the machine. It gives an insight into the internal actions of the machine, which being out of the range of direct observation, are so liable to be misinterpreted. It is to the engineer what the stethoscope and the thermometer are to the physician. Accuracy in measurement is the foundation of engineering and the secret of practical success. It leads to the detection of error, and to perfection in working. No instrument has been more productive of improvement in this respect than Watt's indicator, and few instruments have been found to require less modification. The conception and development of this apparatus showed that Watt was a long way before his time in grasping the doctrine of energy and applying the practice of graphics.

With such an extensive literature on the subject and with its universal employment by engineers, it is unnecessary to describe the instrument.

In his patent of 1782, describing his application of

* Delivered at Greenock February 5, being the "Watt Anniversary Lecture."

the principle of expansion to the economical working of the steam engine, Watt drew a diagram, showing how much he was before his time in the use of graphics, and in the conception of the principle of energy. It is quite clear that this mode of looking at the work done in the cylinder led him to consider its automatic record. It was only necessary to know the length of stroke, and to indicate the pressure of the steam upon the piston exerted during each instant of its movement, to obtain the factors of the work done during each stroke. A curve is thus formed by a pencil on a sheet of paper which by its shape gives the whole history of the performance of the engine. The area of the curve, although it contains nearly all we want, is not that which we require to know so much as its mean height. The horizontal length gives the time of one stroke. The mean height gives the average pressure exerted during the stroke. We thus learn the work done per stroke, and by multiplying this amount by the number of strokes per minute, and knowing the dimensions of the machine, we obtain the total work done per minute.

The principle of work lies at the very root of the profession of the engineer. Watt gave us not only the means to measure it, but a system to indicate it. Work done means resistance overcome. It means the application of force through space against this resistance. In Great Britain we employ as our practical unit the force or weight of one pound. Our space is measured in feet. Thus if we raise one pound a foot high against the resistance of gravity, we do an amount of work which we moderns call a "foot pound," though Watt did not. The foot pound conveys to them who habitually use it the conception of a reality as distinct as one pound of butter. The engineer, like Shakespeare's poet, gives to airy nothing not only a local habitation and a name, but a concrete existence. The French unit of work is larger. It is a kilogramme raised one meter against gravity, and is called the "kilogramme meter." The kilogramme meter contains 7·23 foot pounds.

I have had some difficulty in tracing the parentage of the term foot pound. It came into existence in the forties. Joule, in his earlier papers, spoke of the work done by one pound acting through a foot. Lord Kelvin writes me, "I believe we had 'foot pound' first from Lewis Gordon, the first professor of engineering in Glasgow University (1844), the first really of the United Kingdom. We used it thoroughly in Glasgow when I came from Cambridge to be his colleague in 1846. Joule was much pleased to use it. I believe—in fact, almost remember—that he got it from me."

It is not generally known that James Watt proposed, in 1783, a new and decimal system of weights and measures. His unit length was based on the seconds pendulum. His unit weight was to be the unit cube filled with water, and he proposed to weigh all liquids and gases in terms of this unit in order to express by the same figure specific and absolute weights. There is reason to believe that these ideas were instrumental in framing the splendid system finally made legal in France, in 1801, for Watt himself visited Paris in 1786, and was in intercourse with La Place, Monge, and other members of the committe of the Academy dealing with the question. Nothing can prevent this system, probably the child of Watt, from ultimately becoming universal all over the civilized globe.

Now Watt in introducing the steam engine found the chief competitor he had to meet was the horse. It worked the pumps in mines and "brewhouses." It drew the ores to the surface. It was employed for grinding and for milling. It was clear that his customers would compare the performance of his engines with that of their horses. He determined by experiment that a good horse, working continuously, could raise 22,000 pounds one foot high in one minute. He thought he would go "one better;" so he said, "I will call 33,000 pounds raised one foot high in one minute a horse's power." Thus he gave his customers the advantage of fifty per cent. more work; but he did more. Instead of compelling them to keep relays of horses, each of which could not work continuously more than six or eight hours, he gave them a machine which worked continuously throughout the twenty-four hours. He showed, moreover, that, in Whitbread's brewhouse, his engine "does the work for which thirty strong horses were kept, and consumed $\frac{4}{10}$ bushel of coals per hour."

The above definition of a horse's power was singularly unfortunate. It means fifteen tons moved at a snail's pace. Few people can grasp the conception. We know what a man can do, especially when rowing a race or when raising bricks. Going up a mountain at the rate of 1,000 feet per hour—a fair performance—he does about $\frac{1}{7}$ of a horse's power (H. P.) if he weighs twelve stone. Working a treadmill absorbs one-eighth H. P., which is distinctly hard labor. If he runs up stairs at the rate of $3\frac{1}{4}$ feet per second he does one H. P., and this is not good for his heart. We also know what a horse can do in drawing a cart or moving a canal barge, "550 pounds moved 1 foot per second"—the leisurely pace of a child walking—is more comprehensible than and the same thing as 33,000 foot pounds per minute, and is now more frequently used, especially abroad.

But Watt was not the first to use the term "horse's power." Savery did this in 1702. "An engine," said Savery, "which will raise as much water as two horses, working together at one time in such a work, can do, and for which there must be constantly kept ten or twelve horses for doing the same; then I say such an engine will do the work or labor of ten or twelve horses." Watt, however, gave the unit a scientific character and was virtually its founder.

He thus introduced the conception of power as the rate of doing work. His unit of work was one pound, raised 1 foot high, irrespective of the time in which it was done; but by conceiving this being done in a unit of time he conveyed the idea of power, a scientific definition of a much abused term. Boulton said at court to George III: "I am engaged, your majesty, in the production of a commodity which is the desire of kings." "And what is that—what is that?" asked the king. "Power, your majesty."

Again he was anticipated, for Smeaton, in the Philosophical Transactions for 1759, in describing his experimental inquiry concerning the natural powers of water and wind, said, "The raising of a weight relative to the height to which it can be raised in a given time is the most proper measure of power." Watt did, however, introduce the term "duty" to determine the comparative merits of steam engines. It was introduced by him in Cornwall, and is often known as the "Cornish million," for he determined how many pounds could be raised 1 foot high by burning a bushel of coal in his boiler, and found that this could be expressed only in millions.

Watt's bushel was subsequently changed in this country to 1 cwt. (112 lb.), and in the United States to 100 lb. It has now become practically obsolete, for more effective and more uniform means are adopted to express the relative efficiency of engines.

The term "horse power" has probably seen its best days. It is gradually being displaced, and with the advent of the metrical system it will disappear. As a scientific term it has been much abused, and as a commercial term it conveys no meaning.

Is a horse power really a horse's power? Tredgold made it 27,000 foot pounds per minute for eight hours. Rennie assumed 22,000 as correct. Beardmore had a horse weighing a little over half a ton which did 39,000 foot pounds per minute for eight hours a day. Morin made it 26,150 foot pounds. Two horses will tow a canal boat at 2½ miles an hour, while a steam engine of 10 horse power is needed to do the same work by means of a screw. Tram cars are drawn by two horses at a speed which the so-called 25 horse power motor can scarcely do. The horse is really a more efficient machine for a time than the engine, and its "pull" can be directly applied, but he tires and sickens and dies. He is better adapted to certain kinds of work. He can at times expend much more energy than the so-called horse power. At other times he is helpless and hopeless. Thus it appears clear that a horse power is not a horse's power.

The horse power is based, as I have pointed out, on British units—pounds, feet and minutes.

Scientific men are now universally using a system of units based on the "centimeter," "gramme," and "second"—hence called the "C.G.S." system, to distinguish it from the "F.P.S." or British engineers' system. In this system the unit of work, viz., one gramme moved through one centimeter against unit force is very small, but 10,000,000 of these small units are taken and are called, in honor of our great British experimenter, the "joule," and become a practical unit of work. Thus Joule's own mechanical equivalent, the work absorbed in raising the temperature of 1 lb. of water 1° F. at or about its maximum density, indicated in the "F.P.S." system as 778 foot lb., is in the "C.G.S." system the work absorbed in raising the temperature of 1 gramme of water 1° C., at or about the same maximum density, as 4·2 joules. Thus the joule is to the foot lb. as 1 to 1·356, and the horse power, instead of being 550 foot lb. per second, becomes 746 joules per second. The joule per second, or the unit of power, has now been universally called a "watt;" and thus in the new system the rate of doing work, that is, the power developed by the steam engine, or any other machine, or by any other process, mechanical or physical, is most appropriately indicated in units bearing the name of our great Greenock inventor. The term watt was applied in 1883 by the late Sir William Siemens to the joule per second, but I had previously, in 1881, at the Paris Congress, proposed to apply it to 1,000 joules per second. Siemens' proposal has been preferred, and in consequence the practical unit of power comparable with the horse power becomes the kilowatt. Had my proposal found favor, the practical unit of power would have been the watt, and Siemens' unit would have been a milliwatt. I venture to think the acceptance of my unit would have hastened the departure of the term horse power.

I was surprised and pleased the other day to find in Marseilles that the man directing the electric tram cars in that city, corresponding to the driver of the old horse car, sometimes called in America the motorneer, is called the wattman, and I have since learned that this term is very general in France.

Energy, though so Protean in its character, retains its joule throughout all its changes. Every joule impressed on the surface of the ocean by the rays of the sun adds to the moisture of some cloud which, condensed into rain by contact with our cool highlands, feeds a river.

Thus in every stage of its transformations the joule remains the same mechanical unit, while the energy that it measures outproteuses Proteus.

The grand principle of the conservation of energy teaches us that no energy is ever lost. The total energy present assumes a form either useful or useless to man. The skill of the engineer is devoted to render that which is useless useful, and no one has helped him to do this more thoroughly than James Watt.

The rapid introduction of electrical energy for electric light, for traction and for the transmission of the waste powers of nature to distant places is revolutionizing our systems of units. The British Association, in 1861, formed a committee to consider the question of general electrical measurement, and aided by Wheatstone, Varley, Balfour-Stuart, Siemens, Matthiessen, Clerk Maxwell, Joule, Fleeming Jenkin, who have departed, and Lord Kelvin, who remains as active as ever, they have so impressed the world by their work that, aided by the congresses in Paris in 1881 and 1883, in Chicago in 1893, and in London in 1894, the system proposed has been universally adopted, so that electricians in all parts of the world, whatever their nationality or their language, use the same terms, the same measures, and the same units. The ohm is the unit of the resistance which has to be overcome in any case of the flow of electrical energy; the volt is the unit of pressure which maintains this energy through this resistance; the ampere, the result of one volt acting through one ohm, is the unit of current, and the coulomb is the unit of that electrical quantity which is being driven. These are electrical units pure and simple; but leading from and associated with them are the mechanical units—the joule and the watt.

The watt is universal and exact; the horse power is not. The latter equals in:

	Foot lb. per second.
England	550·00
France	542·47
Germany	582·25

How can one reconcile such discrepancies? The foot pound per second equals 1·356 watt. The horse power therefore equals 746 watts. The watt equals 0·7373 foot pound per second. The kilowatt, 1,000 watts, equals 1·34 horse power.

If, in order to obtain the value of the power, we divide by 33,000 the ordinary formula, A P Sn, where A is the effective area of the piston in square inches, P the mean pressure of the steam in pounds per square inch during one stroke, S the length of this stroke in feet, and n the number of strokes per minute, we get it in horse power. If we divide it by 44,238, we get it in kilowatts. Horse powers multiplied by 0·746 are expressed in kilowatts; and kilowatts multiplied by 1·34 are expressed in horse power. The new system is universally used by electrical engineers.

Names, when well selected, secure precision of language; a watt is a watt and nothing else. A pound, on the other hand, may be either a force or a mass or inertia. Names fix ideas. Every electrical workman has a definite and clear conception of an ohm or an ampere. He requires no definition to impress them on his mind. The name alone conveys to him all he wants to know. They become fundamental ideas. There is no ambiguity, hence there is no difficulty either in teaching or in practice. The same benefits would certainly arise if we applied the term kilowatt to the unit of power. No one would have to ask, "What sort of kilowatt do you mean?"

The same principle which enabled Watt to examine the interior of his cylinder enables the electrician to examine and record the behavior of his plant and his circuits.

Power houses which generate electric currents for supplying electric light or for working trams are generally supplied with recording instruments that tell of the energy expended at each instant of the twenty-four hours. The engineer has thus before him every moment the history of the whole previous day's work. Here, for instance, is a record of a whole day's work in Rome and here a record of another day at the General Post Office in London.

We are able by means of meters to measure water consumed or gas burnt in our premises. The former is sold by the 1,000 gallons and the latter by the 1,000 cubic feet. Similarly we measure the electrical energy that is utilized in our houses and factories by the kilowatt hour, that is, we pay 6d. for every 3,600,000 joules we direct to meet our wants.

ROTARY PUMPS AND ENGINES: THEIR ORIGIN AND LATER DEVELOPMENT.

THE constant failure that has attended the efforts to produce a successful rotary engine, and the fact that the direct acting crank-and-rod reciprocating engine has retained full possession of the field, have led many people to suppose that the rotary engine inventor is as visionary a dreamer as the would-be inventor of perpetual motion. As a matter of fact, however, many of the objects aimed at in the first device are as legitimate and useful as those of the latter are absurd and impossible. While the supposed advantages of a rotary engine, as outlined below, have proved very attractive to the inventor, the results of careful comparative tests have shown that, except in the case of rotary impact engines or steam turbines, the rotary engine does not compare in efficiency with the ordinary reciprocating type.

Undoubtedly the feature that has proved most attractive in the rotary engine is the fact that the piston pressure is always applied tangentially to the circle described by the crank, and so does away with the "dead centers" of the direct acting engine. The turning moment of any given amount of crank pressure upon a crankshaft is the product of this pressure by the vertical distance between the direction in which it is exerted and the crankshaft. In a direct acting engine this vertical distance varies from zero on the dead centers to a maximum just before half stroke, when the crank and connecting rod are at right angles. Consequently a constant and even turning moment can only be secured by coupling two direct acting engines to a common shaft, and placing their respective cranks ninety degrees apart. The piston pressure of a rotary engine, on the contrary, is always exerted tangentially to the circle described by the crank, and consequently its turning moment is always at a maximum. There is, moreover, a loss of power in the direct acting engine by reason of the change of direction of pressure at the crosshead, a certain component of the piston pressure being exerted against the guide bars. This loss is greatest when the crank is near the half stroke and the turning moment is largest. Another alluring feature of the rotary engine has been the fact that the heavier reciprocating parts of the standard type of engine are dispensed with, and that it is not necessary to provide the massive flywheel nor the heavy counterbalance weights of the ordinary machine. Last, and by no means least attractive feature, is the economy of space that is sought to be realized by doing away with piston rods, crossheads, guides and connecting rods and the economy of material and labor that would be realized in manufacture.

Now it would certainly seem that with such theoretical and practical features in its favor, the rotary engine would prove a formidable rival to the standard type. But this it has never done, and for the very practical reason that, owing to its peculiarities of construction, it is difficult to secure an economical regulation of the steam supply and it is impossible to keep the joints steam-tight and prevent irregular wear of the parts. The wear of the piston is always greatest at the circumference of the cylinder, decreasing toward the center, and this structural defect has thus far baffled the efforts of the mechanic. The packing devices that bear against the circumference of the cylinder like the piston rings of a vertical direct acting engine show an equal wear throughout; but no amount of ingenuity has yet succeeded in compensating the variable wear of the side packing. There is a further difficulty in the fact that in rotary engines that have only one admission port the steam pressure produces a rapid side wear on the shaft and renders it difficult to keep the stuffing box steam-tight. Another difficulty is experienced with the valve gear, which in the great majority of rotary engines is of the reciprocating type. Reciprocations which would involve no serious wear at a moderate speed become serious at the enormous speed of the rotary engine and produce rapid wear of the parts.

In looking for the prototype of the rotary steam engine we are carried back several centuries to the year

1588, when Ramelli gave a description of the rotary pump shown in Fig. 1. Our readers will see at a glance that this machine compares favorably with the later rotary engines and pumps, many of which differ from it merely in detail, the leading features being present in Ramelli's design. It consisted of a hub, d, placed eccentrically within a cylinder, a, so that their peripheries nearly touched at a point midway between the suction and delivery pipes. Four rectangular blocks or pistons, c, were arranged to travel in radial slideways cut across the hub. The pistons were kept in contact with the cylinder by their own weight, the center of the hub being above that of the cylinder in the original machine. In the later machines contact was secured, as shown in the cut, by coil springs. The water, entering by the suction pipe, was swept round the cylinder until it reached the delivery pipe, where, being resisted by the abutment formed by the meeting faces of the hub and the cylinder, it was forced out through the delivery pipe.

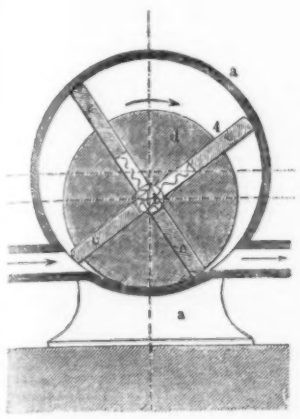


FIG. 1.—RAMELLI PUMP, 1588.

Another, and even more famous, historical pump is that known as the "Pappenheim Rotary Pump," shown in Fig. 2. In the year 1719, Grollier de Servières described it as being in the mechanical collection gathered by his grandfather, and in 1636 Schwenter gave a description of substantially the same machine. It will be seen from the cut that what are practically two spur wheels with rounded teeth were arranged to gear with each other within an elliptical chamber. The sides of the wheels ran closely against the sides of the chamber, and their periphery had just sufficient clearance to turn freely in the semicylindrical ends. A suction pipe was provided in the bottom and a delivery pipe in the top of the chamber. The axle of one of the wheels projected through the side of the chamber and was provided with a crank. When the crank was turned, the water was carried by the teeth round the ends and, not being able to return between the wheels on account of the abutment formed by their contact at this point, it was forced out at the discharge. This, in addition to being among the oldest, is certainly one of the best rotary pumps ever invented. It has few parts and no valves; it is positive and entirely rotary in its motions and fairly durable. It stands as one of the most remarkable inventions of any age; it has the credit of being distinctly original, and it was the prototype of a large number of later pumps and blowers which differ from it mainly in the contour and number of the teeth in the wheels.

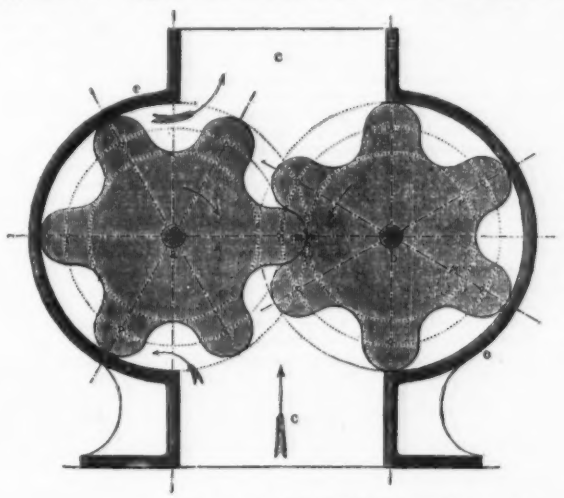


FIG. 2.—PAPPENHEIM PUMP, 1636

In later years the Pappenheim principle has been applied to the design of ventilators and blowers. Fig. 3 shows the first ventilator designed by Fabry, a Belgian engineer. The wheels, a and b, are three-toothed. The profiles have points of contact on each side of the center line, and the air is thus prevented from passing between the wheels. The amount of air delivered is approximately the same as that of a ventilator with the continuous contact of the Pappenheim wheels.

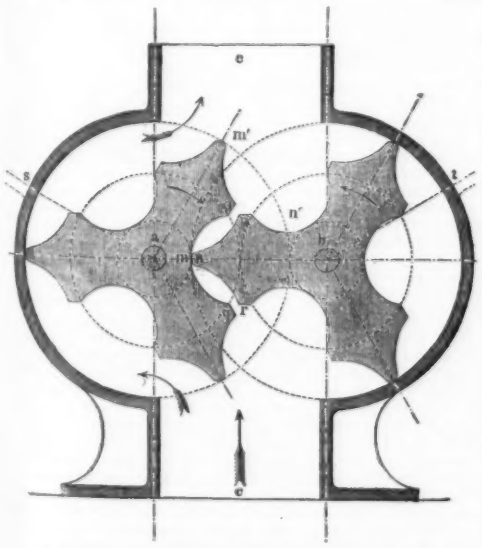


FIG. 3.—FABRY SUCTION VENTILATOR.

Fig. 4 introduces an inventor and a machine which have both become famous. It represents the Root blower which was exhibited at the Paris Exhibition of 1867. Each wheel has two teeth and a circular profile which is continually in contact with that of the other wheel throughout the revolution. This machine has been extensively used, and enjoys a well-deserved popularity. It gives a steady blast of moderate pressure, which renders it suitable for special classes of work.

Fig. 5 shows another form of the same blower. The teeth have cylindrical profiles, which are concentric with and rotate close to the walls of the chamber. Each of these profiles extends through a greater circle, and when it is passing the center it moves almost in contact with the cylindrical hub, p b or q n. To avoid the alternate compression and exhaustion of the air in the space, p n m o, between the points of contact, a slight clearance is left between s o and p b and between r n and q m. This blower does not give so uniform a blast as the first machine.

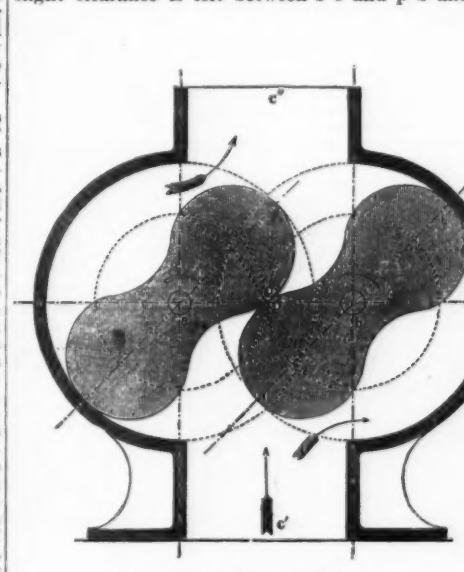


FIG. 4.—ROOT BLOWER, 1867.

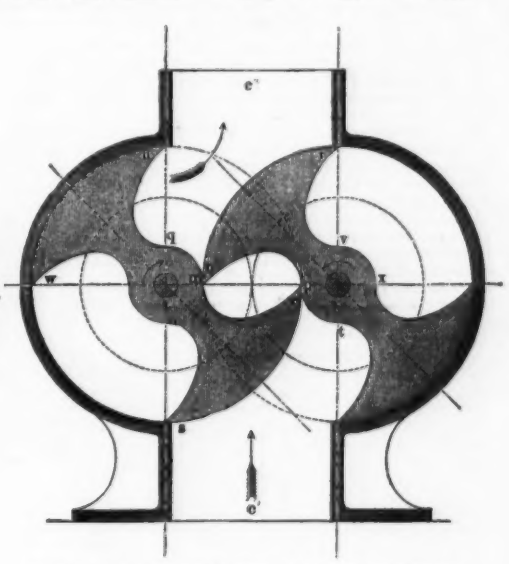


FIG. 5.—ROOT BLOWER, LATER DESIGN.

Repsold's pump, Fig. 6, shows the last step in reducing the number of teeth in a Pappenheim pump. Each wheel has but one tooth. The points of the teeth and the surfaces between their flanks are cylindrical. Wear and Serkis-Balliau exhibited another of the same kind occurs between the point and root cylinders which slide upon one another, and it is difficult to keep the joints sufficiently tight for the use of high pressures.

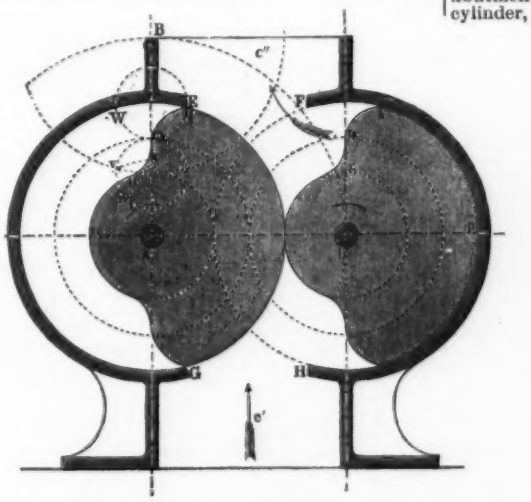


FIG. 6.—REPSOLD PUMP

In all these forms of rotary pumps it is, of course, possible by reversion to constitute them "prime movers." Under a head of water the pumps become hydraulic motors, and the ventilators and blowers may similarly be utilized as compressed air or steam motors. It is scarcely necessary to state that for the latter purposes they would be extremely wasteful, because of the absence of expansion.

Referring again to the machine of Ramelli, it will be seen that organically the inventor has a strong claim to be called the father of the steam rotary engine, just as Pappenheim is undoubtedly the father of the rotary pump. Broadly speaking, all the subsequent inventions and reinventions that consist of a cylindrical chamber, within which rotates a cylindrical driving hub, are modifications of the Ramelli machine, and this is especially true of all those rotary engines which have the hub placed eccentrically within the chamber and form an abutment by the contact of the hub and the walls of the chamber. In Fig. 7 is shown a curious modification of the Ramelli device. The chamber is a distorted cylinder and the piston consists of a block, c, which has a sliding motion across the driving hub, d. The cylinder is distorted so that it shall coincide with the path described by the semicylindrical ends of the piston. Between the admission and exhaust ports an abutment is formed by the contact of the hub, d, and cylinder, a. Franchot built such a machine in Paris,

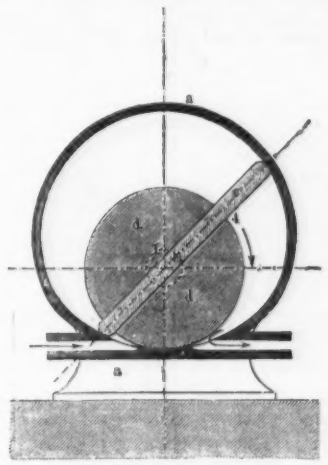


FIG. 7.—FRANCHOT STEAM ENGINE.

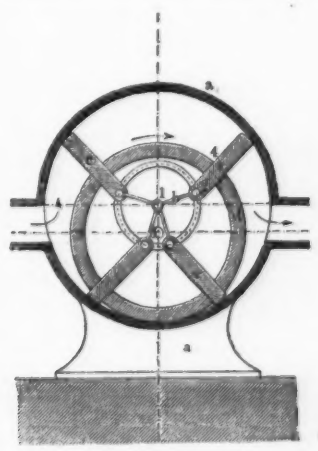


FIG. 8.—EMERY PUMP.

and Serkis-Balliau exhibited another of the same kind in 1867, obtaining a patent for its use as a pump and as a steam engine.

Fig. 8 shows the well known Emery pump, an American invention. It consists of a hollow cylindrical driving hub, d, placed eccentrically within the chamber, a. The four pistons, c, slide in the hub and are guided by the links, b, which connect their inner ends with a pin, 1, on the axis of the cylinder. In later machines the

links were replaced by the circular groove shown in the cut.

The steam engine designed by Lord Cochrane, Fig. 9, though entirely different in construction, is closely related in its mechanical principles to the Emery machine. The piston, c, is hinged to the wall of the chamber and slides in a recess cut in the hub, d. In this case the cylinder revolves on 2 and the hub on 1. Steam is admitted through the center, 1, and passes to the back of the piston by the port shown in

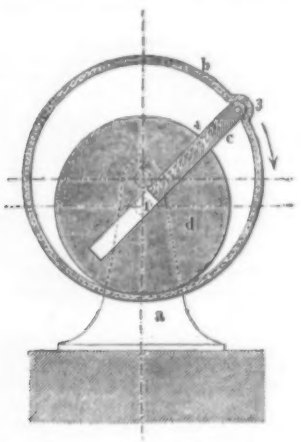


Fig. 9.—COCHRANE STEAM ENGINE.

dotted lines on the piston. Lord Cochrane was an indefatigable inventor of rotary engines, and several of his ingenious machines will be shown in the present article.

(To be continued.)

GAS AND GASOLINE MOTORS.

The Rouen Exposition furnished Mr. Lair-Delay, of Antwerp, an opportunity of publicly showing in operation a gas motor of a type constructed by him and that was highly commended by the jury. This motor, which is called the "Cosmos," is of the four period type, and one of its essential characteristics is extreme simplicity.

Putting to profit the data furnished by the theory of the gas engine, Mr. Lair-Delay, in order to diminish losses through the sides of the motor as much as possible, has recourse to a strong compression and to a running at high speed, which has the effect of increasing the rapidity of the propagation of the flame and of giving a completer expansion. The distributing mechanism consists of two valves, one of which, A, serves for the admission of the explosive mixture and operates automatically, and the other, B, does duty for the eduction pipe, P, and receives the proper impulsions mechanically. The rising of the first is regulated by modifying the tightening of the nuts that compress the spiral spring that surround its rod. This is a simple as well as rapid method of regulating the volume of the mixture to be admitted.

The eduction valve also is pulled back to its seat by a spring after having been lifted therefrom by the rod, G, connected with one of the levers of the horizontal shaft, B¹. This latter carries at the end another lever, C, that constitutes a sort of crank with the preceding, and whose wheel, K, is attacked by a cam, V, keyed upon the distributing shaft, H. It will be seen that this shaft is parallel with the motor and revolves under the action of a bevel gearing whose ratio is two to one. The mechanism that it actuates is sure in its action and not liable to get out of order.

The two distributing valves are arranged in a box, O, closed by an easily removed cover. This box is connected with the cylinder of the motor by a pipe, S, into which pass the explosive mixture and the products of combustion. Moreover, it carries at the side a short tubulure, at the spherical extremity of which end two other tubulures, the three being at right angles with each other. The air enters through the tubulure, U (Figs. 2 and 4), while the gas is admitted through a graduated cock, R (Fig. 1), into the tubulure, T, back of a clack valve whose aperture is subordinate to the action of a centrifugal regulator.

The distributing shaft, H, constitutes the rod of this regulator, the balls of which are connected by jointed levers with a cylinder that carries a collar, upon which, through a shoulder, rests the fork of a socket, Z, which is capable of sliding vertically and participates in the revolving motion of the shaft. At every suction stroke of the motor a cam fixed to the socket acts upon a notched wheel, D, fixed at the end of a rod having a slide that opens the clack of the gas tubulure, T, and brings about the formation of the explosive mixture.

When the motor is at rest the socket, Z, assumes a position such that there exists a certain play between its shoulder and the collar of the cylinder connected with the balls of the governor. During the first revolutions of the motor, after it has been started running, the governor opens without difficulty, and it is only at the moment at which the proper velocity is reached that the collar of the cylinder comes into contact with the shoulder of the socket, Z. Beyond such velocity the governor raises the socket, whose cam misses the notch in the wheel and allows of no admission until the running has become regular again. It is possible by tightening or loosening the milled nut that suspends the governor from the shaft, H, to cause a variation in the angular position of the ball levers and consequently to modify the velocity of running. Such regulating is easily effected and may be done even while the motor is in operation.

The ignition is effected by means of a tube raised to incandescence by an ordinary burner. It takes place spontaneously in the small motors, the tube of which is variable in length and diameter, according to circumstances. In the motors of a certain power the ignition is regulated by a valve which is actuated by a cam mounted upon the distributing shaft.

The frame of the motor is provided with a square base that constitutes a solid seat. The velocity, which for reasons given above is high, varies from 210 to 250 revolutions. The lubrication of the cylinder is assured by an apparatus whose discharge is visible and regulatable at will.

As for the consumption of gas, that is sensibly from 25 to 28 cubic feet per horse hour in the low powers, while a 10 horse power motor consumes scarcely 22 cubic feet.

Mr. Lair-Delay arranges this motor so as to be run with gasoline of a density of 690 or 700, in order to permit of the use of it in localities in which there are no gas works.

The carbureter that he constructs is shown in Figs. 5 and 6. The apparatus consists of a cylindrical receptacle, A, filled with water and surrounding the cylinder, R, which is supplied with gasoline through the open tube, U, which, during the running, serves also for the admission of air.

This tube is guided in a sheath of the cylinder, R, and is carried by a metallic float, F, that is surrounded by a corrugated ring. The air sucked through this tube into the float makes its exit through the corrugations and is immediately brought into contact with the most volatile stratum of the stored up hydrocarbon. The latter, moreover, is always kept at a temperature sufficient to assure the carbureting of the air under the best of conditions. To this effect the tube, H, that traverses the receptacle, A, is placed upon the line of travel of the burned gases going from the motor to the exhaust box. The cooling due to the evaporation of the gasoline is thus efficaciously combated. The water in the part, A, is, in fact, kept tepid all the time. It is poured in through the tube, B, up to the level of the waste pipe, V, which also allows of the outflow of the water that has been used while the supply of A is being renewed.

Upon the cover of the reservoir, R, there is arranged a box containing a small stop valve, D, and carrying a tube, C, connected with the gas cock of the motor through a rubber tube. This small valve rises during the suction stroke of the motor, and upon the float there is exerted an effect of suction that draws the air through the corrugations of its periphery. This air bubbles up through the gasoline, becomes charged with the vapors thereof and, once carbureted, ascends to the upper part of the cylinder, R. Beneath the stop valve, D, there is placed a plate, E, perforated and covered with very fine wire gauze, the object of which is to offer a maximum of security. Everything goes to show that a return of flame cannot occur; but, even did such a thing take place, the valve on the one hand and the wire gauze on the other would successively offer an opposition to the extension of the flame to the carbureting reservoir.

In running with gasoline the consumption of the motor is about ten ounces per horse hour.—Revue Industrielle.

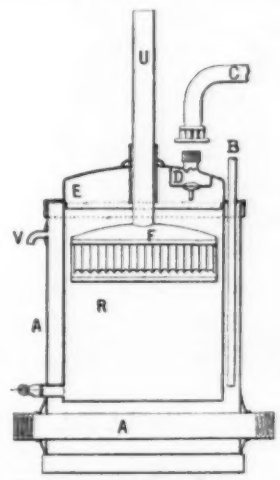


Fig. 6.

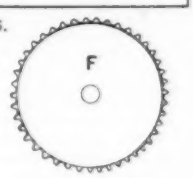


Fig. 5.—Carbureter.

Fig. 1. Fig 2.

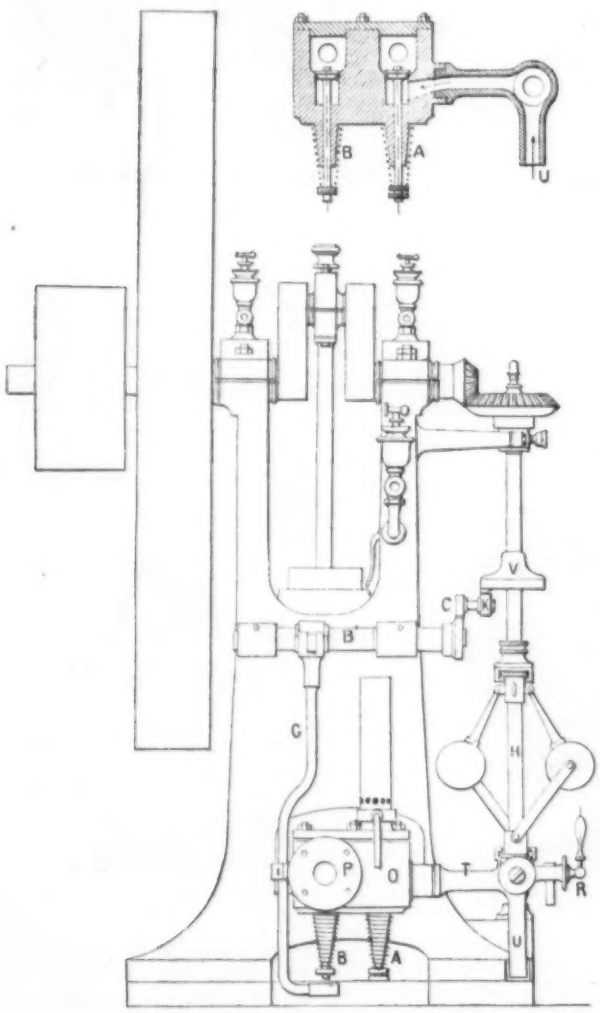


Fig. 3

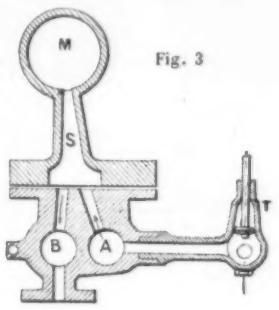


Fig. 4.

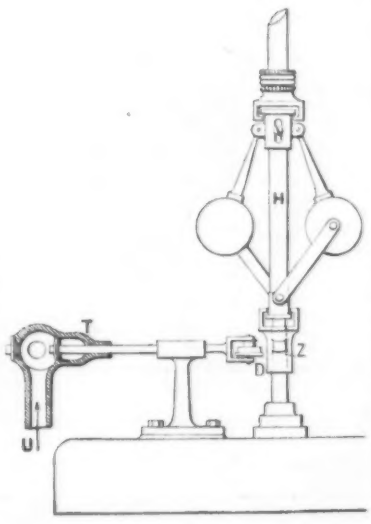


Fig. 1.—Elevation. Fig. 2.—Distribution. Fig. 3.—Horizontal Section through the Distribution. Fig. 4.—Regulator.

THE LAIR-DELAY GAS MOTOR.

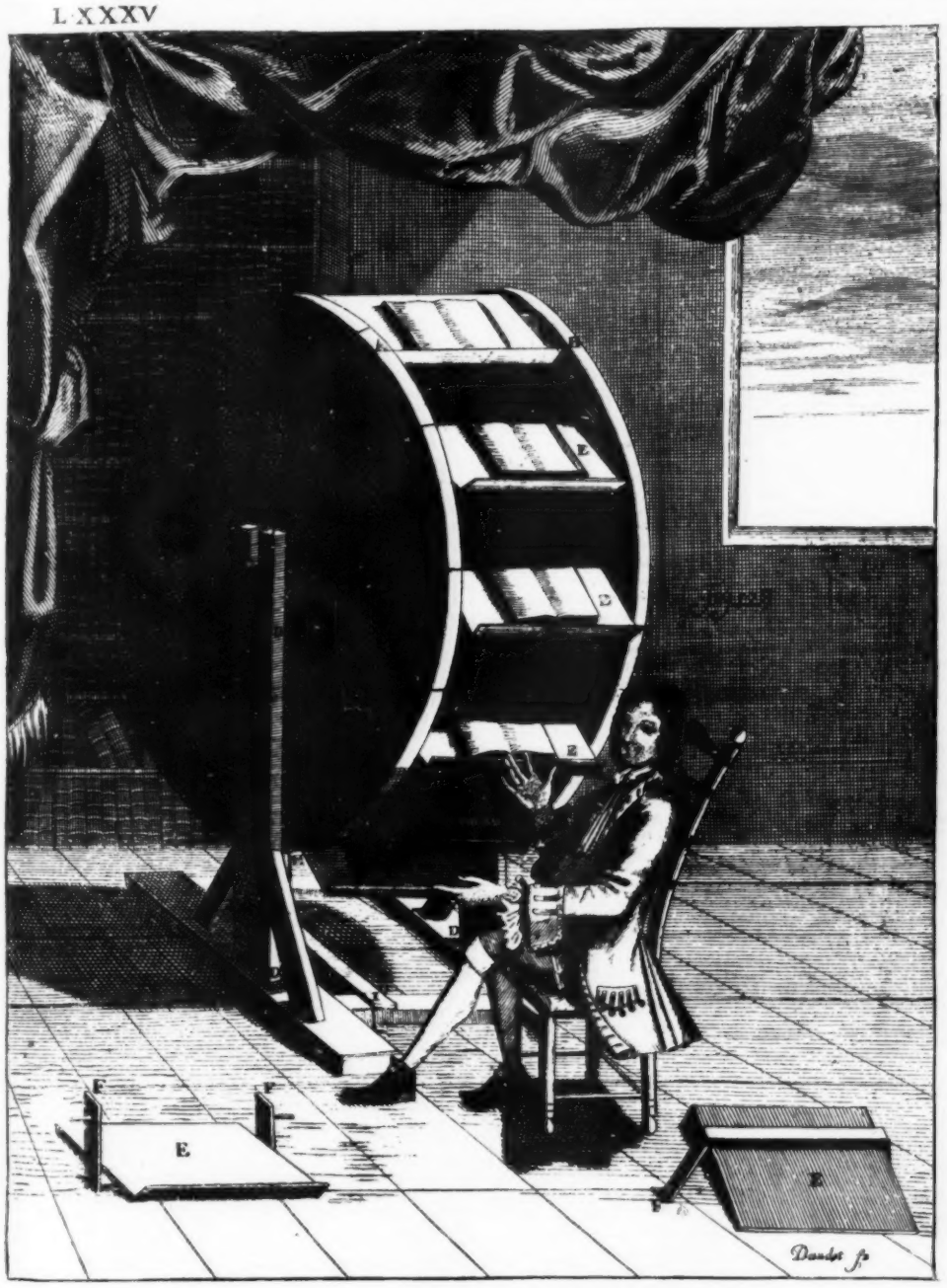
Prof. Roberts-Austen's discoveries on the interdiffusibility of metals have been taken up by the Royal Society of England. The facts have been to some extent known to savants before, but now the results are made more clear. It is shown that solid metals may be made to mix themselves as if the atoms were living creatures. Prof. Roberts-Austen has, in fact, discovered pieces of metal engaged in the very act of mixing themselves with each other. Of course, the interest of this is that the interdiffusion had been found to take place when the metals were cold, and though this property in metals, to be capable of attaching themselves one to the other when cold, has been talked about before, nothing so clearly proved has hitherto been at the service of metallurgists and chemists as the facts adduced by Prof. Roberts-Austen. He shows that when clean surfaces of lead and gold are held together in the absence of air, at a temperature of 40° for four days, they unite firmly, and can only be separated by a force equal to one-third of the breaking strain of the lead. The professor has also proved that if a plate of gold be laid under one of lead about three-tenths of an inch thick, in three days gold will have risen and diffused itself to the top of the other metal in very appreciable quantity.

A CONVENIENT READING TABLE FOR STUDENTS.

IN the Recueil d'Ouvrages Curieux de Mathematique et de Mecanique is described a curious revoluble reading table, shown in the accompanying plate. This desk may be used by persons who are devoted to study and who compose, and principally by those who are troubled with gout, for, by means of this apparatus, you can, without changing your situation and without budging from your chair, read several books in succession; and, far from having to take the trouble to go to get them or to have them brought to you, you easily make them come to you.

The two large wheels, A B, are firmly attached to each other by the axis, C, which makes them revolve together upon the uprights, D. Between these wheels and around their circumference there are shelves or desks, E, which are held by a sort of cranked axle, F. These axles are movable in the wheels, so that when the latter revolve, the weight of the desks holds them always in equilibrium in the same situation and prevents them from losing it.

Before beginning your work you arrange upon the



A CONVENIENT READING TABLE FOR STUDENTS.

desks, E, all the books that you judge you will need. Afterward, having seated yourself in the chair, G, you read the book that first presents itself to you, and when you desire another, you easily make it come to the place of the first by revolving the wheels, A B, by hand.

If your books are of different size or thickness, and all the heaviest are arranged on one side and the lightest on the other, then, as the large ones overbalance the small, your apparatus will always be unsteady, and you will not be able to keep it conveniently in the situation that you desire. So, in order to obviate this, there may be added the stop, H, which, entering notches in the wheel, A, will hold it at the proper point as long as you do not wish to change a book, but which, nevertheless, will allow it to revolve, when, in order to free it, you press your foot upon the detent, I.

Instead of using the apparatus just described, you can arrange your books around a large circular table which you will have so constructed that its top may revolve upon a pivot. This may be easily done by placing the pivot in the center of the table upon one of its legs, and by providing the legs that support its circumference with small rollers. By this method, which is very simple, after you have read the book in front of you and you wish another, you can easily cause it to take the place of the first by revolving the table with the hand.

THE HISTORY OF THE MIRROR.

THERE is great diversity of opinion as to what period can be ascribed the invention of glass mirrors. Some writers assert that attempts were made at Sidon to form mirrors of glass, but being found inferior to those of metal, they were abandoned. This view, however, is not generally accepted, and we have nothing but conjectures and probabilities. The grounds on which many old commentators of the Bible have supposed that glass mirrors were known as early as the time of Moses are very weak, recent learned writers, after an express examination of the question, denying altogether that glass mirrors were used by the ancients. No doubt they would have been invented earlier had glass windows been in use, as reflections from windows would undoubtedly have served as a suggestion for their introduction. Though glass was long held in high repute, particularly at Rome, and though various descriptions of glassware are mentioned in ancient writings among costly furniture, mirrors are classed with silver plate, and only referred to in that connection. In fact, there is no certain trace of glass mirrors from the time of Pliny to the thirteenth century, but from this period they are frequently mentioned, and metal mirrors are no more heard of. The first glass mirrors appear to have been made of a blackish looking glass, or an imitation of the obsidian stone, afterward they were formed of a glass plate, with black foil laid upon it. In a collection of antiques at Leipzig there are glass mirrors covered with this black foil only. At a later period blown glass was covered while hot with a metallic mixture, and still later, plates of glass at Murano were covered with an amalgam of tin and quicksilver, being followed by the casting of glass plates, which, being found too costly, was superseded by blowing and stretching.

The first reliable mention of glass mirrors covered with tin or lead occurs in the thirteenth century, in a treatise on optics by Pecan, an English Franciscan monk. The writer speaks of iron, steel, polished marble, and glass mirrors, and says that the last named were "covered on the back with lead, and that no image was reflected when the lead was scraped off." Bellovacensis, about the same period, also says that "the lead was poured over the glass plate while hot." That this invention was introduced about the end of the thirteenth century is confirmed by the fact that glass mirrors were exceedingly scarce in France in the following century, while mirrors of metal were in common use, that of Anne de Bretagne, consort of Louis XII, being of the latter description. Glass mirrors were not known in Persia and the East until Europeans traded with those remote regions, and metal mirrors were long afterward preferred, being more durable in the dry, hot climate than the amalgam of the glass mirrors, also being less liable to break. The next step in the progress of this art was the application of an amalgam of tin, instead of pouring melted metal over the glass plates. The tin, hammered into thin sheets, was spread out smoothly; quicksilver was then poured over it, and rubbed into it either with the hand or a hare's foot, and the tin covered with paper when thoroughly saturated. The glass was then laid upon it, and while the operator pressed it with his left hand, he carefully drew out the paper lying between the tin and the glass with his right, weights then being placed upon the glass. The process of covering with tinfoil was known at Murano in the sixteenth century, but whether the invention belongs to the Venetians has not been satisfactorily proved; at any rate, their mirrors were obtainable throughout Europe and in both the Indies till the end of the seventeenth century. After this period the glasshouses of other countries came into notice, and many new ones were established. The discovery, made in France, that glass, like metal, could be cast into much larger plates than by blowing and rolling, proved prejudicial to the mirrors made at Venice.

In 1634 glasshouses were established in France for manufacturing mirrors, Grandmont obtaining a patent to this end; his undertaking, however, was not successful. Rivière, valet de chambre to the king, then proposed the manufacture of mirrors according to the Venetian method, and having obtained the royal permission, sold it for a considerable sum to De Noyer, who, in 1665, received a confirmation of the patent, and an advance of 12,000 livres for four years, conditionally on his procuring workmen from Venice, who, after serving eight years in the kingdom, were to be naturalized. De Noyer was joined by Poquelin, who had previously carried on the largest business in Venetian mirrors, and who brought his own workmen from Murano. Glasshouses were then built at Tourlaville, near Cherbourg, where the manufacture was continued till 1684, when the charter of the company was renewed for another thirty years, De Bagneux then being at the head of it. Five years later (1689) Thevart suggested to the court the casting of glass mirrors of much larger dimensions, which after consideration was approved, and in the same year obtained the royal permission and a patent for thirty years. The first plates were cast at Paris, and created universal astonishment, being eighty-four inches in height and fifty inches in breadth. The cost of a furnace for casting the large plates was £3,500; it seldom lasted more than three years, and even in that period had to be repaired every six months. It took six months to rebuild it, and three months to repair. The melting pots were about the size of a hogshead, and held rather more than ten tons of metal. When they burst in the furnace the loss of material and time was estimated at £250. It can readily be imagined, therefore, that only the wealthy could indulge in the luxury of a life size mirror.

A patent for an ingenious process for silvering glass was taken out in 1843 by Drayton. It consisted in depositing silver, from a solution, upon glass by deoxidizing the oxide of silver in solution, so that the precipitate adhered to the glass without the latter being coated with metallic or other substances. In recent years the manufacture of mirrors has almost become a fine art, the growing taste for artistic ornamentation finding, among other things, a subject in mirrors, not only for home decoration, but for business premises, also for advertising purposes, as shown by the large patronage bestowed upon them by brewers and distillers.—Hatters' Gazette.

POSITIONS OF THE MAGNETIC POLES.*

THE American expedition that is preparing, under the direction of Professor Langley, to fix the present position of the north magnetic pole has suggested to Professor Weyer of Kiel the idea of calculating the movements of the poles from long series of observations made at nineteen stations. The stations chosen have their magnetic meridians cut at right angles, and the periods of observation vary from 167 years, at Stockholm, to 369, at Paris. M. Weyer has calculated from these data the position of the magnetic poles for the years 1680, 1710, 1740, 1800, 1830, 1860, and 1890. The position of the north pole was 80° 28′ north longitude and 150° 0′ west latitude in 1680; its latitude and longitude lessened gradually during the century following. In 1800 the longitude was 90° 7′ west, after which it began to increase, and in 1890 it had reached 119° 10′. During this time the lowest latitude, 77° 0′, had been reached in 1830, and the pole rose gradually to 78° 51′ in 1890.

The north magnetic pole, starting in 1640 from 67° 55′ south latitude and 164° 15′ east longitude, moved toward the west during the whole period; its longitude was 93° 23′ east in 1890. Its latitude had increased to 74°23′ south in 1830, after which it decreased, till it reached 72° 29′ in 1890. It may be seen by this that the movement of the poles is very considerable, and that the movement of the south magnetic pole does not correspond to that of the north pole. M. Weyer has put his results to the test by making special researches, which have confirmed their exactness. It is, nevertheless, singular that the position of the north magnetic pole, as it was determined by Ross in 1831—namely, 70° 5′ north and 96° 46′ west—should be so far removed from the position calculated by Weyer—77° 0′ north and 95° 38′ west. As one of the editors of the Deutsche Geographische Blätter remarks, the determination of the pole by Ross is not at all exact, but yet an error of nearly 7° in the latitude seems very large.

In an investigation subsequent to that of which we have just spoken, Weyer finds that in the northern hemisphere the mean directions of the magnetic meridians all meet in a point of convergence whose position is as follows:

Latitude. ..... 82° 50′ north.
Longitude..... 139° 12′ west of Greenwich.

The meridian of 139° 12′ west and 40° 48′ east corre-

* Ciel et Terre (Paris).

sponds, then, to an average declination of zero, and the north pole thus determined can serve to find the mean declination for any station whatever. But the agreement between calculation and observation often leaves much to be desired.

For the southern hemisphere is found, with less certainty, the following pole:

Latitude..... 70° 26′ south.
Longitude..... 108° 36′ east of Greenwich.

TECHNICAL EDUCATION IN EUROPE.*

By C. P. BROOKS, Director of the Lowell Textile School, Lowell, Mass.

WHILE the relations of the European nations during the last twenty-five years have been nominally those of peace, as a matter of fact there has practically been in existence a continuous war, not a contest for military or naval supremacy nor contention for territory, but a struggle for wealth and for the control of the commerce of the world.

In the course of this constantly raging industrial war, Germany has been the antagonist and England and France on their defense; one of the latter nations protecting her world wide trade in high grade, substantially made, and yet cheap goods and the other her tastefully designed manufactures. The strategy brought into play and the weapons used have been very various. Now it has been the superior knowledge of modern languages on the part of commercial representatives; then it has been additional zeal on the part of a country's consular service. Again, it has been the subsidy of a merchant fleet; at another time skill and diplomacy applied to the making of a favorable treaty with another nation. All through the contest the honors have rested with Germany, and many of her merchants will be ready to admit that the success has been in the fact of the inception of technical education and its introduction on a practical basis in Germany before it was adopted by any other country, and in the immense sums that have been spent by states, cities and manufacturers in high grade trade schools and trade instruction, and that they depend for continued success on the extension and elaboration of their present system.

In Germany, the military burdens were heavy, the people were taxed to the utmost, and yet they taxed themselves still further for educational purposes. Money was spent twenty years ago on trade schools, which appeared to Germany's competitors as absolute waste, but now other countries have seen the wisdom of establishing technical schools, and are falling in line. Great Britain is now probably spending four times as much per annum on technical instruction as is being spent by any other nation.

In the last decade German commerce has increased enormously. Hamburg, formerly the sixth largest port in Europe, is now one of the first, if not the first.

Almost every issue of a German trade paper notices the establishment of a new factory or workshop, or an addition to an old one, and the German exports have increased by millions of dollars annually and at a much greater rate than the exports of other nations. Even a protective tariff, such as we have in this country, is insufficient to keep out the results of German taste and skill in design and the low priced products, which are the effect of technical and scientific knowledge, resulting in cheap production. Further increases in facilities for technical instruction in France, Switzerland and Italy are practically at a standstill, but Germany is still extending her system, and as aforesaid, Great Britain has added enormously to the number of technical schools during the past few years.

There are probably twice as many in existence in England now as in Germany, but it will be some years before the full advantage of them will be realized, and meanwhile other nations are reaping the results of their foresight.

It may be worth our while to consider what is meant by the term "technical instruction" or "technical school." A dictionary definition would include everything from a school or rather a university aiming at educating the highest grade of engineers, chemists, and professional men on the one hand and the local school room where evening or Sunday lectures are given to artisans on the other.

Technical schools may be classified under several heads:

First.—What are recognized in England as technical universities, or on the Continent of Europe as higher technical schools, or polytechnics, which are high grade institutions for the scientific instruction of skilled engineers, architects and chemists, and which can best be compared in this country to such as the Cornell University or your own Institute of Technology.

Secondly.—Secondary technical schools, which aim at similar objects as the first grade, but which are not as well endowed or equipped and are frequented by boys and younger men who are merely preparing for business, rather than a profession, and who desire the training in method that such a school can give.

Thirdly.—Combination schools of science, art, and technology, often called technical schools, which are usually evening schools, but in many cases are for the purpose of giving both day and evening instruction.

Fourthly.—Elementary trade schools for the teaching of specific trades, under which head will come manual training schools or apprenticeship schools, and which are represented in this country by such schools as the Manual Training School of Cambridge, Mass., and abroad by the manual training schools which are found in most large cities in England and also by the Fachschulen of Germany and the apprenticeship schools or industrial schools of Belgium and France.

Fifthly.—Perhaps the most important, although not the most numerous class, consists of higher trade schools for specific trades. These schools give trade instruction, to my mind, in the most ideal manner, as I will have further occasion to remark.

All these schools in the abstract come under the name of technical schools, and the instruction given in them under the term technical education, and thus it will be seen that the term covers a very broad field, so broad that for purposes of discussion it is necessary to define what kind of technical education is referred to, or to limit the meaning of the term in some manner.

The phrase technical education may be construed to mean anything pertaining to any art or trade or anything appropriate to the same, and as such may include not only the actual practice of the trade in question but all trades, arts and sciences allied to it. Thus a university of science which is essentially for the training of scientific and professional men may by some people be called a technical school, as it uses the machinery or the apparatus required in any particular trade for the purpose of illustrating the science instruction. In England it is becoming more and more recognized that the phrase "technical instruction" or "technology" should not have so wide a meaning. Thus a school is often described as existing for the purpose of teaching science, art and technology, which proves that there is a recognized difference between technology and science and art. The generally accepted meaning of technology or technical instruction is instruction in the actual practice of the trade or trades, the use, construction and care of the machinery or apparatus employed in that trade, in constructing, working, manipulating, or changing the machinery, and art and science are introduced only to such an extent as is necessary to show their application to this trade or group of trades. The more appropriate name for schools of this kind would be trade schools. In the infancy of the movement, the names "technical schools" and "technical instruction" were applied and are likely to be adhered to. When I thus define the generally accepted meaning in England of "technical school" in this manner, I do not necessarily mean to imply that the trade schools themselves are separate and distinct organizations; in fact, in no country in Europe are the science schools and art schools and technical schools conducted so frequently under the same roof and under the same organization as in England, although they are recognized as being entirely different branches.

The purely trade school has, perhaps, reached its highest stage of development in Germany. As an example of my meaning, I would refer to the school at Crefeld. Here, about 1883, $210,000 were spent in the erection of a school merely for the purpose of teaching weaving and such arts and sciences as were of special interest to the weaving industry, the money being contributed partially by the city, partially by local manufacturers, and partially by the municipality. This school has formed the model for almost every weaving school that has since been erected in any country, and although it has since been equaled, possibly excelled in equipment, it has obtained a reputation for excellence which will adhere to it for many years. The influence of the school on the welfare of the city of Crefeld and, indeed, on the German textile industry, has been most remarkable. Silk goods that were formerly made in France and in England are now made in Crefeld, and are exported to both former named countries. The city has prospered exceedingly, old branches of trade have been extended, new branches of textile industry have been added, and although so large a sum was spent on the school in 1883 (in fact, more than many people considered advisable), it has been found necessary recently to add an annex that nearly doubles the size of the school. The school at Crefeld is equipped with a whole range of complicated machines connected with the dyeing and weaving of textile fabrics, and with its departments for the application of science and art to these industries, affords an instance of the belief of the German manufacturers of the value of the best artistic and technical instruction.

The corresponding French school is the National School of Industrial Arts at Roubaix, which has been recently erected and is on a scale very similar to that of Crefeld, and the school of Crefeld has no doubt served as a model for this institution to some extent.

Schools that serve the same purpose are in existence in other parts of France and Germany, and also in Italy at Como, in Belgium at Ghent, and in Switzerland at Zurich, all having the teaching of weaving and designing as their object and including no other studies than those pertaining to the textile industries, in some cases limiting the instruction to the silk weaving industry only.

Weaving is not the only trade which is taught in special trade schools, but in various parts of the Continent of Europe are to be found schools for the teaching of pottery manufacture, and for the training of jewelers and goldsmiths, for the teaching of hosiery manufacture, lace manufacture, machine embroidery, the building trades and coal mining, watch and clock making and many other industries. Each of these schools is usually under the control of a thoroughly practical man, who is competent to work in all the branches of his particular industry and who has often been a works manager or superintendent of a factory or workshop prior to taking charge of the school, and who has graduated previously from one of the higher technical schools or technical universities.

The schools of horology are very interesting. These exist chiefly in France at Paris, Besançon, Cluses, in Switzerland at Geneva, Bienne, Neuchatel, Le Locle, Chaux de Fonds, and in Germany at Furtwangen.

Undoubtedly the best of these schools is the school at Geneva, which had in 1893 as many as 64 students studying watch making. The school is administered by the city authorities and is supported by grants from the federal government and from the city. The course of instruction extends over five years and is taken advantage of not only by native Swiss, but by many foreigners, including students from United States. At the end of their term of training, the student has the satisfaction of having personally made five or six complete watches, including chronometers, and of having personally constructed or experimented with all the existing apparatus connected with registration of time under any conditions of temperature, magnetism, etc., of having made his own tools during the time he has been in the school, and of being a thoroughly competent craftsman.

So valuable is the instruction given in these purely trade schools in the Continent of Europe that the possession of a certificate enables the student to obtain occupation immediately when he leaves the school, and the services of the graduates of these schools are eagerly sought after by the manufacturers. This is especially true of the weaving school at Crefeld.

I have especially avoided speaking of the English schools in this connection, as their consideration will form another portion of my paper.

The class of schools just referred to forms to my mind the best type of technical schools. A school in which the student can do practical work under as nearly as possible the same conditions as in a mill or works, or rather under a series of variable conditions, such as are found in different mills or works, is the best technical school. Practical work should not be made subservient to theory and the instruction given in science and art should only be so much as is necessary in its application to the particular trade or industry that is taught in the school.

Schools of this kind should be established in the districts in which the industries taught are carried on, and as the cost of equipment and annual expense of a really complete school of this character is considerable, it is obvious that they cannot exist in all industrial centers. Therefore, a central school should be established to serve for a given area and should be run in connection with local lecture courses for the benefit of the artisan, supplied from the central school with skilled traveling lecturers, the central school being attended principally by men who wish to prepare for the positions of superintendents, managers, and overseers.

The only suitable location of schools for teaching industries which are common to every city, such as plasterer's work, plumbing, bread making, confectionery work and book binding, would be in the largest city in the prescribed area, but the natural location of a leather trade or a boot and shoe making school would be in a shoe manufacturing center, a textile school in a textile manufacturing center, a ship building school at a seaport, and so on with a hosiery school and watch making school and others.

Of the five classes of schools already described, Germany is represented in the first class by several admirable technical high schools, of which the one at Charlottenburg may be taken as an example. The slide on the screen indicates the size of this institution, which was built about 1882, at a cost of over $2,000,000, which has accommodation for 2,000 students and 120 professors, lecturers, assistants, and private tutors. The library contains 50,000 volumes, and the building is 750 feet long and 294 feet deep. This school, although possessing admirable facilities for the training of professional and scientific men, hardly comes under any ideal of a technical school, and from the point of view of a practical manufacturer institutions of this kind give instruction which is too theoretical and pedantic for practical business purposes.

The second grade of schools is represented in Germany by the Higher Trade Institute of Chemnitz, in Saxony. Here is an aggregation of technical institutes which have been in existence for about 20 years, and which cost $410,000. The accommodation is for 600 students and the staff numbers about 50. These schools are very numerous in Germany. The work done in them is very thorough and useful, but tends to instruction in subjects intended to be of general use in building, engineering, and mechanical trades rather than to the specific trade instruction of the German and other special trade schools that have previously been mentioned.

Of the third class, combination schools for popular day and evening instruction in science, art, and technology, there are few examples on the Continent of Europe, these being essentially English organizations.

In France the technical university is best represented perhaps by the Central School of Arts and Manufactures in Paris. This is an institution established seventy years ago and has one claim to prominence such as is seldom found in connection with any technical school, which is, that it is supported by the fees of the students. The school is admirable in its equipment and facilities, but the tendency to theory and pedantry is noticeable and has been remarked upon by practical men who have had an opportunity of examining the work done in the school.

To store the mind of a beginner with useful knowledge or to give an efficient mental training, these schools are useful even to the students who intend to devote themselves to business pursuits.

In the other classes of schools France is represented by a few good trade schools, such as those at Roubaix, Lyons, St. Etienne; but the advances of recent years have not been very great and the tendency is toward hermaphrodite combinations of higher technical schools and trade schools, which are not satisfactory.

From every point of view, technical education in Switzerland may be considered very satisfactory. The excellent trade schools, especially watch making and textile schools, have already been remarked upon. The two grades of technical institutions are admirably represented in the secondary grade by the Winterthur Technicum and in the highest grade by the Federal Polytechnic School at Zurich, worldwide in its reputation and admirable in every respect, whether as an example of the liberality of the Swiss nation in providing the highest grade of scientific instruction at a nominal cost, either to natives or foreigners, or unusually thorough scientific instruction in every department, which accounts for the fact that this school has probably more graduates holding responsible positions in their professions than any other European school. Only about one-half of the students in this school are Swiss, the balance being from all parts of this world, including Austrians, Germans, English and Americans. The fees payable only cover one-fifteenth of the total cost. There are several buildings in all, including the Central Building, Forestry and Agricultural School, Physics School and Chemistry School, some of which I now show on the screen. In Italy there are several small examples of each grade of school, including the higher technical schools of Milan and Turin and other trade schools, and the silk weaving school at Como in Italy, established and conducted largely on German lines and doing good work.

(To be continued.)

* A paper read before the Society of Arts of the Massachusetts Institute of Technology, Boston, Mass., March 25, 1897.

It is not generally known, says The Engineer of New York, that Charles H. Haswell, the veteran engineer of this city, now in his eighty-seventh year, and still actively engaged in his profession, was the original discoverer of zinc in marine boilers to prevent scaling; he first used it in 1846, but since that time it has been claimed by dozens of others as their discovery.

ENGINEERING NOTES.

Sir David Salomons is having the old Canterbury and Whitstable engine Invicta carefully cleaned and put in order, with a view to its being placed at the Charing Cross Station, London. This engine was numbered 20 in the books of R. Stephenson & Co., and was completed early in the year 1830.

The new East River bridge contract for the New York tower has been awarded to Patrick H. Flynn, of Brooklyn, for $367,000, under a bond of $250,000. The stone is to come from the New Jersey quarries of Jesse S. Carman. The engineer's estimate for building this tower was $477,000.

A plumber was recently killed in this city under peculiar circumstances, says the American Machinist. He was called in on account of a stoppage of a pipe connected with a boiler. The boiler fire was put out, and there was supposed to be little or no steam on. In the course of operations, the plumber put his mouth to the pipe and blew into it, when there was a sudden rush of steam, which entered his lungs, and he died in a few minutes by hemorrhage.

The Boston subway, the Engineering News shows in an article, is the largest tunnel yet run under streets anywhere; larger than the Blackwall tunnel in London, two to four times as large as the South London Electric Railway, and larger even than the Detroit-St. Clair River tunnel. To August 15, 1896, $1,703,772 had been spent, and work was completed or under contract on 2·94 miles of single track, or 55 per cent. of the total. If the tunnel proves all that is expected, the subway will become familiar in our cities. To-day it would cost less to put small subways under the main streets of this city than to be tearing up the pavement all the time.

The American Association of Master Car Builders has been making experiments on brake blocks. Its committee reports that "for use on steel-tired wheels under the conditions which usually prevail in passenger service, it was difficult to name any one of the several brake shoe metals as certain to produce good results, owing to the fact that very wide ranges of friction were developed, and a very wide range of effect on the tire itself; the result being that cast iron is the only material which can be relied on to give uniformly satisfactory results, both as regards friction, the wear of the brake shoes themselves and the effect of the brake shoes on the steel tire."

The street railways of the United States, says the last edition of Poor's Manual, aggregate 15,956 miles in length, as compared with 13,176 miles last year; in five years the gain in mileage has been 6,294 miles. These lines possess an equipment, so far as the unsatisfactory statistical returns will show, of 28,154 passenger cars, 20,777 motor cars, 206 dummies and 28,621 horses. Since 1891 the number of horses in street railway service has declined 162,000, or about 80 per cent. Out of the above mileage, lines aggregating 531 miles failed to make complete returns of capitalization, etc. The 15,425·42 miles reporting show a capitalization of $828,547,285 in stock and $525,949,928 in bonds; an average of $87,809 per mile in stock and bonds as compared with an average of $60,188 per mile for steam railways.

The obstructions to navigation, shoals, rapids, etc., on the Zambesi River have always contributed largely to the excessive cost of transport from the coast to British Central Africa. It is now proposed to construct a railway from Kiliman to a point on the British Central African border just above the rapids on the Ruo River, a distance of 190 or 200 miles. A decree of the Lisbon government has recently been published authorizing the Zambesi Railway Company, a Portuguese corporation, to issue four per cent. bonds to the amount of £1,400,000 ($6,813,000), redeeming at par in 65 years or less. This sum will constitute the capital of the company, and will be expended in constructing and working the said railway, which must be completed by the end of the year 1900. Any manufacturer of railroad supplies or equipment wishing to do business with this company must go to Lisbon, where the head offices are located, and there negotiate with the leading officials.

Our German contemporary Glückauf mentions an instance of the ignition of coal dust by the sun's rays, says the Engineering and Mining Journal. The surface works of the Maybach Colliery, near Friederichsthal, in the Saar district, are chiefly of iron. On certain girders, the floating dust, due to the tipping of coal on to the jigging screens, became, in course of time, deposited in a layer more than an inch thick. On a mechanic burning his hand—while repairing a pipe running through the corrugated iron forming one of the south walls—the official inquiry showed that the layer of coal dust had been formed along the whole length of the wall. Although the dust contained a proportion of pulverized rock, the metal plates heated by the sun had ignited it, the layer of white ash on the top proving that it had burned for a considerable period. This circumstance affords, in addition to fresh proof of the remarkable ease with which coal dust may be brought to ignition, a possible explanation of fires at similar surface works.

We have several times referred to the work carried on at the Berlin Institute of Raoul Pictet by Dr. Altschul, on chemical reactions at very low temperature, says the Trades Journals Review. The January number of the Zeitschrift für die Gesammte Kalte Industrie produces several pages of tables on the freezing points of mixtures of sulphuric acid and water. As in former instances, two series of observations were made, the one starting from water and admixing acid in molecular proportions, the other starting from concentrated acid. The investigations have an essentially theoretical interest. Altschul separated the liquid from the frozen mass by means of a vacuum, and titrated the sulphuric acid. His curves are irregular, and cross the zero line five times. For instance, an 80 per cent. acid of specific gravity 1·734 freezes at + 1·5° Cent., a 77 per cent. acid at — 14°; an acid of 73 per cent. at — 70°; one of 57·65 per cent. at — 58°; with 5 per cent. we pass into the + again, and an acid of 0·5 per cent. sulphuric acid freezes at — 0·5°. There seems to be no connection between the concentration and the freezing point; but the existence of several definite hydrates is confirmed.

ELECTRICAL NOTES.

An International Electrical Exhibition is to be held at Turin in 1898. The executive committee and the special commission invite exhibits from all parts of the world, and the exhibition will embrace the following classes: 1, Apparatus for teaching electrotechnics; 2, materials for conduction of electricity; 3, instruments for electric and magnetic measurements; 4, telegraphs and telephones; 5, signaling apparatus and safety appliances on railways, lighting and heating of carriages; 6, dynamos and motors; 7, mechanical appliances and electric traction; 8, electric lighting; 9, electro-chemistry and electro-metallurgy; 10, miscellaneous; 11, apparatus of historic interest.

The world's submarine cables now number more than thirteen hundred, according to the recent presidential address to the London Institution of Electrical Engineers. They have an aggregate length of 162,000 nautical miles, over half of them being less than five miles long, while eight of them exceed 2,000 miles. They represent a total expenditure of about $200,000,000, about 75 per cent. of which is British capital. A fleet of forty-one repair ships is maintained. The electrician can localize the breaks in a cable closer than the captain can sail his vessel, yet a break on one of the Anglo-American lines costs almost half a million dollars to mend, this being probably the most expensive repair on record. It is possible to transmit nearly fifty words of five letters each per minute on the Atlantic cables by an automatic transmitter.

The significant results obtained by Lord Kelvin in connection with his experiments on the effect of Roentgen rays upon the conductivity of paraffin would seem to justify the definite placing of the paraffin conductor theory among Prof. Silvanus Thompson's grand army of X ray myths. Lord Kelvin does not refer to a very crucial experiment of Mr. Nikola Tesla upon this very same point, in which Mr. Tesla was quite unable to satisfy himself as to the existence of the alleged phenomenon, says The Electrician. The correct explanation would certainly appear to be that the apparent conductivity of paraffin is due to "the augmentation of the electrostatic capacity (quasi condenser) of the brass ball by the outside surface of its coat of paraffin being put into conductive communication with the surrounding lead sheath and the connected metals."

The great objection urged against the use of gas engines for electric light purposes, says the Mechanical World, is their unsteady running. With the use of the Otto cycle the operation must, in the very nature of things, be unsteady; and the one thing that would have tended to counteract the unsteadiness (an extra heavy flywheel) was discountenanced by many gas engine makers, mainly because it would have told slightly against the economy of the machine. It is satisfactory to observe, however, that in the very latest engines put down for electric lighting—namely, at the electricity works of the Leyton District Council—the makers have recognized the importance of the flywheel, for, although the engines are of 55 brake horse power, the weight of each flywheel is a little over 5 tons, which is probably more than twice the weight usually employed for a steam engine of similar capacity.

The electric letter box is by no means an unfamiliar device. As the postman's mail is dropped into the street door box, electric contact is made and a bell is rung in the kitchen. This is a very simple and admirable provision against the possibility of an important letter that may demand an instant reply lying unnoticed in the box. A variation of this device is now used for calling the attention of postal clerks to the incoming of special delivery letters. The invention, which is credited to a former letter carrier, consists of a slanting box, at the lower end of which there is a sheet of metal working on swivel points. When the letter is dropped into the box it slides down upon the metal sheet and holds the lower edge down, thus making an electric circuit that rings a bell continuously until somebody goes to the box and lets the letter out, which is done by unhooking and raising the front part of the box. Electric letter boxes are the newest addition to the apartment houses.—The Electrical Journal.

Among the private bills which have already passed their first reading is that by which Parliamentary powers are sought for the project known as the West Suburban Railway, a line four and a half miles in length, which is intended to run from Praed Street, Paddington, to Acton lane, Willesden. The district through which it will pass is one tenanted largely by a population of clerks, mechanics, and small shopkeepers. This railway will be an overhead light electric line of ordinary gage. The first two and a half miles, says The Engineer, will be carried on a viaduct formed of steel columns 50 ft. to 70 ft. apart, supporting lattice girders, the height of the rails being from 14 ft. to 17 ft. above the road. It is proposed to have no fewer than 11 stations on this short four and a half miles' run. There will probably be seven or eight minutes' service, and the whole journey, it is estimated, will take 25 minutes. The trains will be at first of two cars, of a kind somewhat similar to those in use on the City and South London Railway. The cost will be under $500,000.

The Madrid correspondent of the Times writes: "The telegraph system throughout this country has always been a crying scandal, and instead of improving with the times and the advance of science, it appears to get worse. The most ordinary atmospheric disturbance is sufficient to render unserviceable the greater part of the lines throughout the country, while a heavy fall of snow or a gale of wind generally results in a complete paralyzing of the whole service. Under this condition of things it might fairly be expected that the authorities would not place additional difficulties in the way, and that the public convenience would be to some extent taken into consideration; but it is not so, and the inefficiency of the office is only on a par with the defective state of the materiel. Further, the senseless and useless censorship which is exercised by the home office, without the slightest discretion being used as to the nature of the contents of the telegrams detained, results in hours of delay. Two telegrams sent the Times a short time ago were detained nine hours before they were dispatched."

MISCELLANEOUS NOTES.

The oldest wooden building in the world is said to be the church at Borgund, in Norway. It was built in the eleventh century, and has been protected by frequent coatings of pitch. It is built of pine and in fantastic Romanesque design.

The publishers of the Rugby Advertiser were put in a very disagreeable position by the breaking down of the gas engine they used for running their presses. They finally hit upon the expedient of hiring the steam roller of the town and connecting it to their presses by means of a belt. The scheme worked very well.

According to a calculation worked out by the Revue Scientifique, of Paris, the proportion of paying load to total displacement of a steamship in 1840 was only 10 per cent. That is, the hull, engines and fuel carried formed 90 per cent. of the weight of the vessel. In 1850 the paying load had risen to 26 per cent.; in 1860 to 33 per cent.; in 1870 to 50 per cent. At the present time the Atlantic steamers show an average of 55 per cent. paying weight. The advance since 1870 has been comparatively slow, chiefly because much higher speeds are now required.

The authorities at the head of the industrial exhibition at Nürnberg in 1896 have tackled the matter of the business results directly traceable to the exhibition in a very practical manner, having sent forms with questions to all the exhibitors. From the answers it appears that the sales number 7,117, representing an aggregate value of 1,881,769 marks (or about $470,000) and that the orders number 8,828, representing an aggregate value of 1,500,017 marks (or about $375,000). The sales and orders are classified under seventeen different heads, machinery being at the top of the list with over $250,000.

A shorthand writing machine has been invented in England. The London Times describes it as being very portable, measuring 8 by 7 in. by 4 in. high. It is virtually silent in operating and may be described as a miniature typewriter, with only six keys. By the various combinations of these keys, struck with either hand, a species of Morse shorthand of dots and dashes is produced on a roll of ordinary thin paper. It prints in regular lines across the sheet and automatically shifts from one line to another. The inventor claims that the system is easier to learn than ordinary "pencil shorthand."

A novelty in the way of row boats is being made by the Pneumatic Row Boat Company, New York. The boats are made of waterproof canvas and rubber in four distinct air tight compartments. While said to be not easily punctured, if that should happen the manufacturers say a boat full of water will still sustain in safety all who can get in it. They are regularly made in four sizes, 7 ft. to 16 ft.; they have wood or air cushion seats, as desired, with metal row locks and wood base, buckled into an upper air chamber. It is said that two or three of these boats of ordinary size can be carried in an average traveling trunk.

The birth-rate is decreasing not only in European countries, but in America also, as statistics show, says The Medical Times. "In 1880, the birth-rate per 1,000 in the United States was 30·95, while in 1890 it was only 26·68, a decrease of 4·27 per 1,000 of population in ten years. The decrease was greatest in Massachusetts, 11·67, next in Virginia, 7·76, and even in New York it was 1·76. It is a question if this decrease in the birth-rate is an evil after all. Horticulturists do not think that a tree loaded with fruit gives as fine results as when the culture and the strength of the tree is centered in a smaller amount. In the latter the fruit is larger, richer in flavor, and more valuable than in the former. So long as the nation is increasing year by year in population, we need have no fear of a near extinction, even if the families are smaller than a half century ago. Parents who bring into the world more children than they can properly care for are by no means to be commended. Quality is much more to be commended than quantity."

The profitable utilization of the great masses of waste glass accumulated at factories is now accomplished in a comparatively easy manner by M. Garchey, a Frenchman, says the American Manufacturer. He grinds the waste glass and puts the powder into a metallic mould, which is introduced into two furnaces in succession, in order to devitrify the mass; the first furnace serves for the gradual annealing of the mass, so that all the parts are devitrified as uniformly as possible; the mould remains about one hour in this furnace. Owing to their pulverized condition, the glass molecules are finely separated and suffer very quickly the devitrifying action of the heat. Becoming soft, the molecules weld together and form a very consistent dough. In this condition the mould is taken out of the furnace and put into the second furnace that is heated to a very high temperature. In this furnace the mould is left for only a very few minutes, this second operation being intended to complete the devitrification and to make the mass more pliable. The substance is now in a condition to be pressed into different shapes, there being produced in this manner all kinds of ornamental or other building "stone," which is generally called ceramic stone.

A novel kind of flooring has been provided in the power station of the Edison Electric Illuminating Company, of Paterson, N. J., says The Engineer. This floor consists of a huge casting of cement forming the undivided floor of the entire station. The floor proper is 4 in. in thickness, but at intervals of 15 ft. there is cast on the back or under side of this 4 in. web a beam 18 in. in depth and 9 in. in width, running crosswise of the station and resting upon the supporting piers of brick. The floor is further stiffened by longitudinal ribs 14 in. in depth, and tapering from 4 in. to 6 in. in width, placed 3 ft. 6 in. apart, running between the heavier crosswise beams lengthwise of the station. These stiffening projections are a part of the main casting, so that the floor is virtually one immense casting of cement, with stiffening ribs on its under side, supported upon brick piers. The floor is completely fireproof, and is said to cost less by one-third than a floor involving the use of iron beams, while it affords a firm foothold, and presents a surface sufficiently smooth to be easily kept clean. It will be interesting to learn what effect oil will have upon it.

SELECTED FORMULÆ.

Javelle Water.—The following formula is given in the National Formulary, viz.:

Potassium carbonate	58	grammes
Chlorinated lime	80	"
Water enough to make	1,000	"

Mix the chlorinated lime, contained in a tarred flask, with 400 grammes of water. Dissolve the potassium carbonate in 300 grammes of boiling water and pour the hot solution into the mixture first prepared. Shake the flask well, stopper it, set it aside to cool, and then add enough water to make the contents weigh 1,000 grammes. Allow the suspended matter to subside and remove the clear solution by means of a siphon or by straining through muslin.

Easter Egg Dyes.—

BLUE.

(1.) Marine blue, B. N. (aniline colors)	60	grains
Citric acid	600	"
Dextrin	2	ounces av.

BROWN.

(2.) Vesuvin, S.	1	ounce av.
Citric acid	1¼	" "
Dextrin	1	" "

GREEN.

(3.) Brilliant green, O	225	grains
Citric acid	300	"
Dextrin	2½	ounces av.

ORANGE.

(4.) Orange, II	150	grains
Citric acid	300	"
Dextrin	2½	ounces av.

RED.

(5.) Diamond, fuchsin, I, small crystals	60	grains
Citric acid	300	"
Dextrin	2½	ounces av.

ROSE.

(6.) Eosin, A	75	grains
Dextrin	3	ounces av.

VIOLET.

(7.) Methyl violet, 6 B	60	grains
Citric acid	300	"
Dextrin	2½	ounces av.

YELLOW.

(8.) Naphthol, yellow, S	225	grains
Citric acid	600	"
Dextrin	2¼	ounces av.

About 75 grains of the powders should be wrapped in waxed paper and put up in a package, which will be sufficient for at least five eggs.

The directions should read as follows: Dissolve the dye in a porcelain or earthen vessel in one pint of boiling water, stirring until solution is completed. In the meantime boil five well washed eggs in water for five minutes, then transfer them to the dye bath, and allow to remain until sufficiently colored, turning the eggs about occasionally. Then dry them with a soft cloth, without pressure, and rub with oil until they appear glossy. The remaining dye can be used for more eggs if desired.—From the Standard Formulary.

Fluid to Preserve Soles, also to render them nonslipping. Following is a formula given by the German chemist E. Soxhlet:

Turpentine	50	grammes
Resin	200	"
Benzine	50	"
Alcohol	250	"

Put in a bottle in a warm place until dissolved. Apply the solution two or three times on the soles and let them dry.—Der Stein der Weisen.

Renewing Wall Paper.—There are several ways by which wall paper can be cleaned so that it looks almost as good as new. Take a loaf of bread, stale, but not too hard, and cut off one crust; then, taking it in one hand, rub the paper gently with the exposed surface. When the bread looks soiled, cut off a very thin slice and proceed with the work. It is best to rub up and down on the paper, and clean each place thoroughly before leaving it. Another way is to take a loaf of bread, and, after removing the crust, soak it in cloudy household ammonia. It must be so wet that one can work it in the hands into a ball. Rub the paper lightly with it, and as the ball becomes soiled on the outside, knead it until a clean surface is exposed. This will remove the dirt and smoke and freshen the paper wonderfully. Another plan is to make a soft dough of coarse brown flour mixed with water; it should be stiff enough to handle easily. The paper can be rubbed with it as in the former method. When there are grease spots on the paper, lay coarse brown paper over them, and pass a hot iron over it. Fresh paper may be needed several times if the spot is large. When there are spots from which the color has been removed, they can be made to look as good as new by the use of water color paints. The design should be traced first, and the filling then put in with the paints.

The Action of Oil on India Rubber.—There is a general belief that oil has an injurious effect upon rubber, and to a large extent that is pretty well proved. It would seem, however, that the power to injure depends very much on the kind of oil used. According to Mr. W. L. Terry, who writes on this subject in the India Rubber Journal, the hydrocarbons, as petroleum and resin oils, are least injurious, while the animal and vegetable oils, represented by sperm and rape, are most destructive. After discussing the effects of certain chemical changes which these oils undergo, in rather a long article, he says there are oils in the market which profess to be without action on rubber, but he cannot say he has found this contention to hold good in practice, and he does not expect ever to find any such oil. Of course, as things are at present, rubber has a certain life, and is consequently valuable, and it is well known that there are certain mixings in the trade which are much superior to others for oil-resisting purposes, but there is still much room for improvement, and the ideal oil-resisting rubber is not yet before the world.

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